

Experimental and Research Station,
Nursery & Market Garden Industries'
- - Development Society, Limited. - -

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Introduction.

THE occurrence in 1934 of a second unusually hot and sunny year has been particularly useful, because it has been possible to obtain more information concerning the reaction of glasshouse plants to this kind of weather. This information has confirmed both the results of past experiments and last year's experience and will be a guide to future cultivation during hot summers.

Membership of the Society, under whose auspices the experiments are conducted, is open to all growers and interested persons. Subscriptions are payable at the rate of two guineas for each acre of glass cultivated by the subscriber; in return members receive future publications and any advice which is available. Members continue to be enrolled, but many more are needed, both to provide additional funds for research and to obtain complete co-operation in controlling the various pests and diseases common to glasshouse plants. Serious outbreaks over a wide area must be fought by all growers; isolated attempts to control disease are almost bound to fail.

Endowment Fund.

An endowment fund has been opened to receive contributions from those who desire to further the work of the Station. The amount collected is now £405. The capital is invested in Trustees and the interest only will be used for (a) future development, and (b) repayment of debt.

It is hoped that those who can possibly contribute to this fund will do so, and so help to secure the Station's future financial prosperity.

Current Investigations.

Manurial and crop management trials with tomatoes have been continued. Past experiments have shewn that the tomato crop in the experimental houses is not improved either in weight or quality by the addition of phosphate but it was considered advisable to arrange a new experiment which would be suitable for statistical examination, and would decide the value of phosphate to this crop. This was conducted with the co-operation of the statistical department of Rothamsted Experimental Station and the results shewed that the omission of phosphate for one year was without significant effect upon the crop.

The improvement of glasshouse soils by the process of placing clean straw in the soil with the haulms vertical was tested further. In a house where straw had been applied to the soil for 1933, the treatment was repeated on one side while the other side was steamed. The crop from the soil to which straw had been added during two years, was considerably higher than that during the year previous to the first application, but there was no marked improvement over last year, whereas the crop from the steamed soil, approximately 47 tons per acre, shewed a considerable increase.

The results of this experiment and of several others on commercial nurseries suggest that the effect of steam sterilization could be improved by applying clean straw to the soil in a vertical position prior to turning on the steam. This will be tested during 1935.

The variety trials shewed again that hot sunny summers are favourable to the types Kondine Red and Radio, for as during last year these come near to the top of the list. A new type J.H. raised by Mr. J. Harnett of Hoddesdon gave the highest yield of 48 tons per acre, being followed by Radio with 44 tons per acre and various Kondine Red types.

The F.1. generations of several new crosses were grown. The parents were selected carefully as being likely to yield new types combining earliness with heavy crops of high quality fruit.

A large experiment was conducted to test the commercial possibilities of the process of warming the soil by circulating hot water through narrow pipes buried some two feet below the surface. Previous results were confirmed: the crops were heavier and the roots both cleaner and more extensive, but the percentage crop increase was not so great as in previous years. This may be due to the fact that the natural soil temperature was 7°F. above the usual temperature during the early part of the season. The experiment shewed that the process of soil warming is likely to prove of the utmost value in commercial work for it ensures a uniform and healthy crop even in soil which has previously failed to react to any treatment except steam sterilization. Indeed soil warming may ultimately replace steam sterilization to some extent.

A new experiment was arranged to test the effect of mixing fertilisers with the subsoil as well as the surface soil, but no improvement was obtained. Examination of the roots at the end of the season showed little development in the subsoil owing apparently to bad physical conditions and it is considered advisable to postpone any further experiments on this problem until it is possible to devise means for improving the physical state of the soil to the necessary depth.

The effect of overhead damping was examined further and it was shewn that heavier crops result from continuing the damping process throughout the whole season. The reason for this is that during the height of the summer the atmosphere in the houses is too hot and too dry for satisfactory fertilisation of the flowers.

The cucumber experiments were concerned with the effect of raising the bed temperature either by means of

electrically heated wires or by circulating hot water through narrow pipes buried under the beds. Only in one case did the heated bed yield a heavier crop than the control, but this is so different to previous results that some other influence is assumed to have masked the effect of soil warming. As in the tomato houses the natural soil temperature was abnormally high and therefore the conditions in the beds were more suitable for satisfactory root development than is usually the case. Further, the bed temperatures were thermostatically controlled during the period of heating, whereas during previous years the beds have been heated only during the night. The relative effect of warming the beds during the day and night will be examined in 1935.

The selection of Cheshunt Early Giant lettuce is being continued. An excellent crop of well-hearted lettuce was produced for the Christmas market, and this variety is maintaining its earlier promise, for it produces large firm hearts during the short days of the year.

Experiments with the Iron Fireman type of stoker were continued. The apparatus, which uses a cheap form of soft coal has shown an appreciable saving in fuel consumption, and being controlled thermostatically it provides a more uniform temperature in the houses than can be obtained by hand firing.

An investigation into the economic status of the Greenhouse Symphylid (*Scutigerella immaculata* Newp.), in relation to the tomato plant indicates that the Symphylid is *not* responsible for injury to the roots of the tomato plant.

The parasite (*Comedo opaculus* Thoms.) was successfully carried over the winter in the pupal stage, and was bred up to the end of July. Owing to the poor adaption of this parasite to its host, the tomato moth caterpillar, the project of distributing it has been abandoned.

In May, some Lady-birds (*Stethorus punctillum* W.S.) known to be predatory upon the Red-Spider Mite were received from Mr. R. Schimp, of Hoelyhart, Belgium.

They were successfully reared during June, but the stock died out during the heat of the late summer. It is unlikely that this insect would adapt itself to temperatures obtaining in a tomato house.

Extensive experiments were carried out with cuprous cyanide as a substitute for Paris green in Woodlouse Baits. Owing to the decomposition of the former compound when mixed with bran and dried blood the results obtained in glasshouses proved inferior to those obtained with Paris green.

Suspensions of lead arsenate, cryolite (formula as given in the Annual Report of 1933, p. 71) and finely divided cuprous cyanide were respectively tested as sprays with a view to the control of Tomato-moth caterpillar (*Polia oleracea* L.), cryolite again proved a satisfactory substitute for lead arsenate, while cuprous cyanide gave results similar to the latter. The uncertainty as to the poisonous nature of cuprous cyanide precluded any recommendation as to the advisability of its use for this purpose.

A glasshouse of 3,000 cubic feet capacity, containing soft-grown tomato plants in large pots has been fumigated with hydrocyanic acid gas according to Collinge's formula 1912. The plants were in no way injured, and the economic possibilities of this treatment will be pursued in the near future.

In connection with the investigation of Leafy Gall of the chrysanthemum, an attempt has been made to clean infected stocks by systematic propagation from healthy plants only. Some improvement has been noted but the results are not entirely conclusive.

The investigation of rose diseases has been continued. Infection by *Coniothyrium rosarum* has been proved in numerous plants which have died on rose nurseries during the past season, and there is no doubt that this fungus is responsible for a great deal of damage. The work is being continued.

Experiments with rose rust have provided some evidence to show the existence of different strains. Thus a strain from *R. rugosa* will infect the cultivated rose, but not *R. laxa*, while a strain from *R. canina* and *R. laxa* has not yet been found to infect the cultivated rose. This aspect of the disease is being investigated in greater detail. In a series of experiments lasting from October, 1933 to July, 1934, germination of the teleutospores was not obtained.

Experiments with oil in copper emulsions for the control of rose rust have been continued but satisfactory control of the disease has not been obtained without damage to foliage.

The cyclamen is being cultivated more extensively each year, and from the number of enquiries received it is clear that attack by eelworm is increasing rapidly. Many substances have been tested as a soil drench but so far without success. Owing to the seriousness of this pest growers are advised to cultivate this crop only in sterilized soil.

For many years growers of Winter Cherry, *Solanum capsicastrum* have experienced serious losses and many have ceased to cultivate it for this reason. The problem came under close investigation during the past season, when it was found that on one nursery about 40% of the plants were attacked by *Phytophthora* sp. Other cases suggest that this figure is largely responsible for the serious losses in the past. Control can only be obtained by cultivation in clean or sterilized soil, using a clean water supply.

A serious disease of cultivated heaths *Erica hyemalis* and *Erica nivalis* has also been traced to infection by a *Phytophthora*, probably *P. Syringae*. This may be the same disease which, at frequent intervals, descends upon this crop ; a full investigation is being made.

As the result of prolonged investigation it is now possible to recommend a method for sterilizing lettuce seeds, which can be used by the commercial grower.

Preliminary work on the "vernalization" of lettuce seeds has suggested that the temperature of germination may be an important factor in the subsequent life of the plant.

Collections of fungi, mainly *Fusaria*, from "root rots" of lettuce and runner beans have been made. Such fungi, associated with "soil sickness" and unhealthy root systems, require specialised conditions for attack. Normal inoculation work has been inconclusive and chambers in which plants may be grown under controlled conditions are in course of construction. The number of bacterial leaf rots of lettuce which have been received from growers, has called attention to the commercial importance of this group of diseases. A collection of the organisms is being made.

Fungi isolated from rhubarb have been tested for pathogenicity but the results were disappointing. Parallel inoculations with bacteria are in progress.

Work on the wilt of the carnation has been resumed. As suggested in the 1928 Report, *Fusaria* other than those named have proved pathogenic. A species of *Verticillium* has been found to be the main cause of wilt upon one badly affected nursery. The conditions leading to the wholesale destruction of carnation beds and the possibility of transmitting the diseases in cuttings from nursery to nursery are receiving attention.

During the year a comparison of English and Canadian virus diseases of tomato was completed. This investigation, carried out in collaboration with workers at the East Malling Research Station and Rothamsted Experimental Station, has shown that the commoner virus diseases of tomato are the same in both countries.

In connection with the above work the various tomato virus diseases of this country were critically examined and certain slight changes in nomenclature have been proposed and are detailed in this Report.

The examination of mosaic diseases of the cucumber was continued. Three types of cucumber mosaic are now recognised and the nomenclature of this group of diseases has been revised.

The attention of growers is drawn to the fact that smoking tobacco frequently contains active viruses (of twenty-six samples of commercial tobacco tested during the year only three were virus-free) and is probably one source from which outbreaks of tomato mosaic may originate.

A large number of chemical substances have been isolated from the soil of nurseries where virus diseases have caused serious injury over a number of years. Young tomato plants have been grown in solutions and suspensions of these substances in water and in soil to which the substances had been added, to ascertain if they are able to produce virus diseases in the plants. Some of these substances were injurious to plants when present in minute amounts in aqueous solution but in no case were symptoms of virus diseases observed in the plants.

Additional work on the preparation of fungicides and combined fungicide-insecticide mixtures has been undertaken with special regard to the control of rust on roses and both leaf mould and the red-spider mite on tomatoes.

The work on light and temperature in relation to assimilation and translocation has been continued but although interesting results have been obtained by studies on seedling plants much remains to be done before the methods can be applied to large plants at the stage of fruiting.

The conditions of water uptake and loss by tomato leaves are being investigated and the results suggest that the usually accepted "percentage water content" of the whole leaf may fail to give a satisfactory index of the conditions obtained in the assimilating tissue.

The effect of rate of change in length of day on metabolism is under investigation and indications have been obtained that a close correlation may exist.

Analysis of chrysanthemum plants grown with various manurial treatments show that the interesting relation between phosphatic fertilisers and potash absorbed already reported for tomato foliage is not so pronounced in the case of chrysanthemums. The plants were grown in soils which had received the same treatment for some years and the treatment, omitting dung, was continued during the life of the plants. The ash, potash and phosphoric acid contents were highest in those chrysanthemums grown in soil which received complete artificials plus dung, and were lowest in those which were unmanured or which had received complete artificials without potash. The omission of phosphates, nitrogen or potash respectively lowered the ash and potash contents of the plants. Omission of phosphates or of potash but not of nitrogen lowered the phosphoric acid contents. Preliminary analyses of the "normal" and "blotchy" pulp from blotchy tomato fruit indicate that the "normal" pulp contains rather more potash.

Several cases of damage to tomato plants of various ages have been traced to the use of chlorate weed killers. Attention is drawn to the necessity of exercising the greatest care in the use of these compounds anywhere near houses, etc., where plants are to be grown.

Obituary.

It is with profound regret that we record the death on July 3rd, 1934, of our beloved President, H. O. Larsen, Esq., J.P., C.C., D.C. Nearly forty years ago, Mr. Larsen, then a Danish student in this country, was attracted to the cultivation of crops in glasshouses, and long before the Great War broke over Europe he had become a specialist in the cultivation of peaches. How he sent regular consignments of these fruits to New York is now ancient history. As with peaches so with all the plants he cultivated and before long he was recognised as one of the leading growers of tomatoes in the country.

Mr. Larsen was an enthusiastic supporter of the Experimental Station of which he was one of the founders. His labours on its behalf were unfailing, and by his generous gifts he contributed in no small measure to its success. He left a legacy of £2,000 towards liquidating the debt which the Station has incurred during its development.

It was, however, the character of the man which made him so universally loved by those who came in contact with him. A cheerful smile, a boyish laugh, an encouraging word, a helping hand and a distinct sense of justice endeared him to all.

Mr. Larsen was a scientific farmer and grower, a man whose keen business instinct was rarely at fault, a man who but for the whim of circumstance might have been a successful statesman. He was a leader with a sense of proportion and tolerance rare in these days.

DIRECTOR'S REPORT.

1. Experimental Results of 1934.

1. Tomatoes.

Growers of early tomatoes except those in specially favoured localities are not likely to remember 1934 with any degree of satisfaction, for the mild sunless weather in February encouraged a soft rapid growth without adequate root development. The crops were light, the roots became diseased and the plants finished early.

Those who planted in March, however, were much more fortunate, for conditions were favourable to growth and fruit production. Crops were good and the plants lasted well. Many heavy crops were reported and that produced in the experimental houses was a record.

If any lessons are to be learned from 1934, it is the necessity for steady balanced growth during the early stages, and the advantages of high nitrogen manuring during hot sunny summers. From the experimental viewpoint 1934 has been an important year for, following an equally hot sunny summer, it enabled more information to be obtained in regard to the question of adapting manurial treatment to suit prevailing weather conditions.

The practice of grading the tomato fruits from the experimental plots, adopted in 1921, was continued during the present season. The fruits were collected in numbered baskets and graded in eight grades as follows:—

- A.—“Pinks” number 5 to 7 and “Pink and White” 8 to 10 to the lb. These are the best quality of fruit in size, shape and colour; “Pinks” being slightly larger than “Pink and Whites.”
- B.—“Whites.” These fruits are of good colour but smaller than “Pink and White.”

- C.—“Blues.” This grade consists of fruits of good colour but larger and more irregular in shape than Grade A.
- D.—“Roughs.” Small mis-shapen fruits about the size of cherries.
- E.—Blotchy fruits which ripen irregularly.
- F.—Fruits shewing Blossom End Rot.
- G.—Fruits shewing the lesions of Stripe Disease.
- H.—Fruits shewing “Green Back.”

(a) Houses 3 and 4. Fertiliser experiment.

In view of the fact that past experiments have indicated that the tomato crop at Cheshunt is not improved either in weight or quality by the addition of phosphates and that no injurious effects occur when phosphates are omitted it was decided to submit this problem to statistical examination, by arranging a suitable experiment which would decide the value of phosphates to this crop. In addition, the relative effects of sulphate and muriate of potash were also examined.

This was done with the assistance of the Statistical Department of the Rothamsted Experimental Station, especially Dr. D. J. Watson and Mr. F. Yates to whom our grateful thanks are due.

Six plots in House 3 and eight plots in House 4 were used, the experiment arrangement being illustrated in Figure 1.

Stable manure was not applied to any of the plots, but they were top dressed during the season with dried blood to provide the necessary amount of nitrogen.

The results are given above in Table 1, and the report of the statisticians is as follows:—

“The standard error per plot, 8·40% is quite reasonable. The treatments have produced no significant effects. From the results it is possible to assign limits to the true magnitudes of the differences. The difference between sulphate and chloride of potash is unlikely to be greater than 8% of the main yield, and the response to phosphate is unlikely to be greater than $6\frac{1}{2}\%$.”

These results shew that no effect of a magnitude detectable by the experiment has been produced this year by adding phosphate or by the different forms of potash. With regard to phosphates, this is in keeping with the results of previous experiments and it seems safe to assume that generally speaking the effect of phosphate on the tomato crop has been greatly over-estimated.

No. 3

No. 4

Figure 1.

$P_1 K_2$	$P_2 K_1$	$P_1 K_1$	K_1
K_2	K_1	K_2	$P_2 K_2$
K_2	K_1	K_1	K_2
$P_2 K_2$	$P_1 K_1$	$P_1 K_2$	$P_2 K_1$
$P_1 K_2$	K_1	KEY K_1 Sulphate of Potash K_2 Chloride of Potash P_1 Superphosphate P_2 Bone Meal	
K_2	$P_2 K_1$		
K_1	$P_2 K_2$		
$P_1 K_2$	K_2		

Variety—"Ailsa Craig."

Table 1.

House	Plot	Treatment	Crop in Lbs. per Plant						Total Tons per Acre	Average Tons per Acre
			June	July	Aug.	Sept.	Oct.	Total		
3	2	Sulphate of Potash ...	1.62	1.69	0.53	0.86	0.62	5.32	40.37	44.36 ± 1.48
"	10	" " " "	1.39	2.63	0.78	0.93	0.36	6.09	46.28	
"	11	" " " "	1.16	2.69	0.65	0.94	0.30	5.73	43.54	
"	13	" " " "	1.32	1.78	0.44	0.93	0.51	4.98	37.84	
4	6	" " " "	1.40	3.25	1.11	1.01	0.39	7.16	54.43	
"	9	" " " "	0.87	2.81	0.86	0.79	0.42	5.75	43.70	43.87 ± 1.48
3	3	Chloride of Potash ...	1.43	1.52	0.37	0.87	0.30	4.49	34.12	
"	6	" " " "	1.33	2.11	0.69	0.89	0.41	5.43	41.56	
"	7	" " " "	1.18	2.95	0.95	0.82	0.44	6.34	48.18	
"	16	" " " "	1.28	1.75	0.48	0.91	0.43	4.85	36.86	
4	7	" " " "	1.28	3.43	1.10	1.12	0.44	7.37	56.01	
"	11	" " " "	1.29	2.95	0.92	0.71	0.25	6.12	46.51	41.90 ± 2.10
3	1	Sulphate of Potash and Superphosphate	1.29	1.37	0.48	0.85	0.66	4.65	35.34	
"	12	" " " "	1.28	2.13	0.55	1.00	0.35	5.31	40.35	
4	8	" " " "	0.78	3.25	1.20	1.02	0.33	6.58	50.00	45.00 ± 2.10
3	4	Chloride of Potash and Superphosphate	1.39	1.86	0.67	0.91	0.41	5.24	39.80	
"	8	" " " "	0.87	2.65	1.15	0.71	0.41	5.91	44.91	
4	5	" " " "	1.24	2.88	0.99	0.87	0.61	6.62	50.31	41.09 ± 2.10
3	9	Sulphate of Potash and Bone Meal	0.74	2.50	0.77	0.94	0.29	5.24	39.82	
"	14	" " " "	1.44	1.64	0.52	0.96	0.33	4.89	37.16	
4	12	" " " "	1.21	2.57	0.96	0.91	0.44	6.09	46.28	41.43 ± 2.10
3	5	Chloride of Potash and Bone Meal	1.29	2.01	0.56	0.86	0.49	5.21	39.55	
"	15	" " " "	1.38	1.72	0.41	0.99	0.46	4.96	37.69	
4	10	" " " "	1.11	2.95	1.16	0.74	0.24	6.19	47.04	

Mean Tons per Acre=43.24.

Standard Error per Plot=3.63 Tons per Acre=8.4%.



The experiment suggests that applications of chloride of potash are equal to sulphate of potash, but this must be regarded strictly as a one season experiment, and growers must not jump to the conclusion that it is true generally. The use of chloride of potash on commercial nurseries is not advised, because chlorides in excess are injurious. They should continue to use sulphate of potash which has proved so effective in the past.

(b) Wheat Straw experiment.

The use of clean straw as a means of improving tomato soils has been examined experimentally both on commercial nurseries and at the Station for several years. The most suitable method of application was described in the 19th Annual Report, 1933, pages 27 to 29. This has been tested in House 2 during the past two years. In 1933 it was applied to both sides of the house, excluding the path, and although the crop was not increased appreciably there was much greater root development and more regular growth. Further, when the soil was dug for the 1934 crop, it was noticed that it had been lightened considerably and was easier to dig than in previous years. The subsoil, in particular shewed definite improvement. For 1935, the east side of the house was treated with straw again in the recommended manner, while the west side was sterilized by steam. The results are given in Table 2.

It will be seen that the effect of steam sterilization has again justified its cost, but it is a little difficult to understand why the straw treatment has not given the anticipated improvement, especially in view of excellent results which have been obtained in commercial nurseries. The method is new and it is obvious that more information is required before it can be applied with maximum effect under all conditions. Growers can assist materially by conducting experiments on their own nurseries. Help of this kind will be appreciated.

Experiments suggest that the beneficial effect of steam sterilization can be increased when straw is applied to the soil during the process and the method will be discussed later in this Report.

(c) Variety Trials.

The variety trials were continued in House 5. They included the F.1 generations of certain new crosses which had been made in an attempt to produce a good early tomato. The results are given in Table 3.

Table 3.

Variety Trial.

Variety	Crop in Yield in Lbs. per Plant						Total Tons per Acre	Quality of Fruit: Percentage in Grade			
	May	June	July	Aug.	Sept.	Oct.		A.	B.	C.	D.
"J.H."	—	0.76	2.24	2.10	0.93	—	6.03	45.83	3	33	1
Radio ...	—	1.70	2.73	0.63	0.76	—	5.82	44.23	20	2	4
Mayland Beauty ...	—	1.18	2.88	0.67	0.97	—	5.70	43.32	17	1	3
Mayland Conqueror ...	—	0.97	2.92	0.90	0.87	—	5.66	43.01	21	4	7
Market King ...	—	1.62	2.95	0.64	0.44	—	5.65	42.94	17	17	4
Bides Recruit × Kondine Red, F.1	—	1.30	2.95	0.74	0.62	—	5.61	42.63	15	4	4
W. Douglas ...	—	1.00	2.90	0.82	0.78	—	5.50	41.80	73	6	3
Bides Recruit × Potentate, F.1	—	1.60	2.35	0.65	0.89	—	5.49	41.72	15	15	8
Kondine Red × Knaresboro' ...	—	1.38	2.73	0.73	0.63	—	5.47	41.57	20	4	5
Potentate × Radio, F.1 ...	—	1.49	2.59	0.68	0.71	—	5.47	41.57	16	10	6
Mayland Bountiful... ..	—	0.76	3.23	0.61	0.85	—	5.45	41.42	9	31	4
Potentate × Kondine, F.1	—	1.64	2.52	0.66	0.62	—	5.44	41.34	51	14	4
Blaby × Kondine, F.1 ...	—	1.67	2.39	0.67	0.62	—	5.35	40.66	62	11	3
E.S.1 ...	—	1.47	2.34	0.65	0.87	—	5.33	40.50	76	18	3
Mayland Perfection	—	0.99	2.70	0.56	0.93	—	5.18	39.37	74	2	3
Tuckswood × E.S.1	—	1.21	2.73	0.52	0.65	—	5.11	38.83	63	9	2
K.C.B. ...	—	1.61	2.28	0.53	0.63	—	5.05	38.38	74	17	3
Blaby × Potentate, F.1 ...	—	1.67	2.00	0.73	0.59	—	5.01	38.07	55	11	5
Tuckswood × Up-to-date	—	0.79	2.71	0.55	0.58	—	4.63	35.19	36	14	4
Stirling Castle × E.S.1 ...	—	0.65	2.12	0.99	0.87	—	4.63	35.19	68	23	2
Paul's S. × C.3 ...	—	0.33	2.16	1.20	0.92	—	4.61	35.03	23	2	6

Table 4.

House	Plot	Treatment	Crop in lbs. per plant						Total Tons per Acre	Average Tons per Acre
			June	July	Aug.	Sept.	Oct.	Total		
11	1	Fertilizer in top 10 inches	0.19	2.63	1.48	1.28	0.44	6.02	45.75	36.63
	2	" " " "	0.22	2.23	1.37	1.08	0.41	5.31	40.36	
	4	" " " "	0.06	2.25	1.32	1.09	0.32	5.04	38.32	
	6	" " " "	0.14	2.41	1.29	0.84	0.35	5.03	38.22	
	1	" " " "	0.10	1.80	1.25	0.82	—	3.97	30.16	
	3	" " " "	0.09	2.22	1.40	0.76	—	4.47	33.98	
	4	" " " "	0.04	1.93	1.71	0.82	—	4.50	34.21	
	7	" " " "	0.09	1.63	1.48	1.02	—	4.22	32.07	
11	3	Fertilizer in top and second 10 inches	0.15	2.51	1.35	1.17	0.46	5.64	42.87	36.69
	5	" " " "	0.06	2.37	1.45	0.88	0.23	4.99	37.92	
	7	" " " "	0.19	2.25	1.23	0.92	0.44	5.03	38.22	
	8	" " " "	0.17	2.41	1.48	1.07	0.39	5.52	41.94	
	2	" " " "	0.07	1.92	1.32	0.96	—	4.27	32.45	
	2	" " " "	0.03	1.56	1.74	1.05	—	4.38	33.29	
	5	" " " "	0.03	1.75	1.67	0.84	—	4.29	32.60	
	6	" " " "	0.06	2.08	1.44	0.92	—	4.50	34.20	
12	3	" " " "	0.15	2.51	1.35	1.17	0.46	5.64	42.87	36.69
	5	" " " "	0.06	2.37	1.45	0.88	0.23	4.99	37.92	
	7	" " " "	0.19	2.25	1.23	0.92	0.44	5.03	38.22	
	8	" " " "	0.17	2.41	1.48	1.07	0.39	5.52	41.94	
12	2	" " " "	0.07	1.92	1.32	0.96	—	4.27	32.45	36.69
	2	" " " "	0.03	1.56	1.74	1.05	—	4.38	33.29	
	5	" " " "	0.03	1.75	1.67	0.84	—	4.29	32.60	
	6	" " " "	0.06	2.08	1.44	0.92	—	4.50	34.20	
12	3	" " " "	0.15	2.51	1.35	1.17	0.46	5.64	42.87	36.69
	5	" " " "	0.06	2.37	1.45	0.88	0.23	4.99	37.92	
	7	" " " "	0.19	2.25	1.23	0.92	0.44	5.03	38.22	
	8	" " " "	0.17	2.41	1.48	1.07	0.39	5.52	41.94	
12	2	" " " "	0.07	1.92	1.32	0.96	—	4.27	32.45	36.69
	2	" " " "	0.03	1.56	1.74	1.05	—	4.38	33.29	
	5	" " " "	0.03	1.75	1.67	0.84	—	4.29	32.60	
	6	" " " "	0.06	2.08	1.44	0.92	—	4.50	34.20	
12	3	" " " "	0.15	2.51	1.35	1.17	0.46	5.64	42.87	36.69
	5	" " " "	0.06	2.37	1.45	0.88	0.23	4.99	37.92	
	7	" " " "	0.19	2.25	1.23	0.92	0.44	5.03	38.22	
	8	" " " "	0.17	2.41	1.48	1.07	0.39	5.52	41.94	
12	2	" " " "	0.07	1.92	1.32	0.96	—	4.27	32.45	36.69
	2	" " " "	0.03	1.56	1.74	1.05	—	4.38	33.29	
	5	" " " "	0.03	1.75	1.67	0.84	—	4.29	32.60	
	6	" " " "	0.06	2.08	1.44	0.92	—	4.50	34.20	

As in the previous year, the hot sunny conditions favoured the Kondine Red types, as is shewn by their position in the table.

Some advance has been made with the leaf mould resistant types, but the fruit is still too small for ordinary commercial work. New crosses have been made with the object of remedying this defect. The F₁ generations will be grown in 1935.

(d) The addition of fertilizers to the subsoil.

A new experiment was conducted in Houses 11 and 12, to determine if there is any advantage in adding an equal amount of fertilizer to the subsoil as is usually given to the top ten inches. Each house was divided into eight plots, in four of which bone meal, hoof and horn and sulphate of potash, 4 ounces per square yard each were mixed with the top soil only, and in the remainder a similar quantity was also mixed with the subsoil. The results are given in Table 4.

As can be seen from this Table the addition of fertilizer to the subsoil was without effect, but when the roots were examined at the end of the season, it was observed that they did not penetrate below a depth of twelve inches, and therefore could not be expected to have utilised any fertilizer in the subsoil.

The experiment will be discontinued until it is possible to devise means for improving the subsoil to such an extent that deeper root action can be obtained.

(e) Overhead damping.

The effect of overhead damping was tested in the Chambers of House 6. In Chambers 1 and 5 the plants were damped overhead each day through the whole season except when the weather was exceptionally wet and cold. In No. 4 damping ceased after the fifth truss had set, while in No. 2 damping was not started until most of the flowers on the fifth truss had set. Chamber No. 3 was not damped at any time.

The results given in Table 5, shew the importance of overhead damping during the cultivation of the tomato. The chambers in which damping was performed throughout the entire season, Nos. 1 and 5 yielded 54.49 and 48 tons per acre respectively. Where damping continued from the fifth truss onwards the yield was 50.9 tons per acre and where the bottom five trusses only were damped it was 42.86 tons per acre. The control, undamped Chamber gave 43.85 tons per acre.

Table 5.

House	Chamber	Treatment	Crop yield in lbs. per plant						Total Tons per Acre
			June	July	Aug.	Sept.	Oct.	Total	
6	1	Damped overhead throughout the whole season	0.80	2.64	1.64	2.09	—	7.17	54.49
	2	Damped overhead from 5th truss onwards	0.13	2.30	2.08	2.19	—	6.70	50.92
	3	Not damped overhead	0.21	2.27	1.72	1.57	—	5.77	43.85
	4	Damped overhead up to the 5th truss	0.18	2.64	1.15	1.67	—	5.64	42.86
	5	Damped overhead throughout the whole season	0.11	2.61	1.60	2.00	—	6.32	48.03
	6	Soil kept at temperature of 80°F. air not heated	0.04	2.10	1.45	1.32	—	4.91	37.32

This experiment confirms what previous observation has already suggested, namely that fruit formation is most prolific where sufficient moisture is present around the flowers.

There is no doubt but what overhead damping is a process which leads to greatly improved "setting." In the Station houses it does not increase the amount of leaf mould when applied suitably.

This being so, growers are advised to test in their own houses the effect of continuing the process of overhead damping throughout the season.

(f) Soil Heating.

The investigation of the effect on the tomato crop of raising the soil temperature by artificial means was extended to Houses 8 and 9.

It will be remembered that for the previous season, an attempt had been made to warm the soil on the gravity system in House 10, by 2-inch pipes buried beneath the soil and that although a considerable increase in yield was obtained, it was not easy to keep a constant soil temperature throughout the twenty-four hours and in every part of the beds. Consequently an alternative system was used during 1934 in Houses 8 and 9. In this, pipes of 1-inch internal diameter were buried 2 feet below the soil surface and connected to the 2-inch flow and return from the boiler installed for 1933.

On the east side of House 8 and the west side of House 9 they were placed 2 feet 6 inches apart and on the other sides they were placed 2 feet apart. Houses 7 and 10, were treated in the same manner as Houses 8 and 9, but the soil was not heated; they were used as controls. The results are given in Table 6.

The average crop from the control plots amounted to 47.52 tons per acre and that from the heated soil 56.84. The increased yield of slightly below 20% is not so great as usual, but this may be due in part to the abnormally high soil temperatures which occurred naturally in the glass-houses last year.

The outstanding features of the results are as follows:—

- (1) The excellence of the root system.
- (2) The uniformity of the plants.
- (3) The ease with which the fruit set.
- (4) The increased earliness.

Table 6.

Variety—E.S. 1.

House	Plot	Treatment	Crop Yield in Lbs. per Plant						Total Tons per Acre	Average Tons per Acre
			June	July	Aug	Sept.	Oct.	Total		
7	5	Control ...	1.11	3.02	1.14	1.14	0.37	6.78	51.53	49.32
"	6	" ...	1.17	2.95	1.29	1.02	0.37	6.80	51.68	
"	7	" ...	1.12	2.61	1.11	0.99	0.35	6.18	46.96	
"	8	" ...	1.07	2.68	1.33	0.89	0.23	6.20	47.12	
8	1	Soil heated 80°F.	1.27	2.84	1.69	1.45	0.31	7.56	57.46	57.94
"	2	" "	1.16	2.84	1.70	1.54	0.21	7.45	56.61	
"	3	" "	0.99	2.87	1.58	1.77	0.28	7.49	56.93	
"	4	" "	0.80	2.89	1.22	1.54	0.46	6.91	52.52	
"	5	" "	0.80	3.63	1.97	1.56	0.73	8.69	66.04	
"	6	" "	0.92	2.80	1.50	1.44	0.41	7.07	53.72	
"	7	" "	1.12	2.88	1.79	1.35	0.48	7.62	57.92	
"	8	" "	1.24	3.03	1.89	1.63	0.37	8.16	62.02	
9	1	Soil heated 80°F.	0.94	3.03	2.01	1.52	0.28	7.78	59.12	55.74
"	2	" "	0.81	3.04	1.80	1.53	0.47	7.65	58.14	
"	3	" "	0.60	3.30	1.68	1.79	0.48	7.85	59.66	
"	4	" "	0.33	3.33	1.79	1.51	0.60	7.56	57.46	
"	5	" "	0.23	3.13	1.36	1.55	0.57	6.84	51.99	
"	6	" "	0.30	2.99	1.69	1.49	0.52	6.99	53.12	
"	7	" "	0.43	2.77	1.54	1.62	0.58	6.94	52.74	
"	8	" "	0.60	3.01	1.55	1.36	0.54	7.06	53.66	

Table 6 (continued).

House	Plot	Treatment	Crop Yield in Lbs. per Plant					Total Tons per Acre	Average Tons per Acre
			June	July	Aug.	Sept.	Oct.		
10	1	Control	0.50	2.72	1.32	1.02	0.47	45.83	45.72
"	2	"	0.40	2.66	1.53	1.16	0.53	47.72	
"	3	"	0.41	2.60	1.38	1.12	0.48	45.53	
"	4	"	0.20	2.58	1.08	1.22	0.54	42.71	
"	5	"	0.21	2.75	1.13	1.15	0.26	41.80	
"	6	"	0.33	2.88	1.28	1.05	0.30	44.38	
"	7	"	0.33	2.93	1.50	1.31	0.27	48.18	
"	8	"	0.49	3.19	1.60	1.00	0.25	49.63	

(5) The improvement shewn in House 8 where the average yield in 1933 was only 31.1 tons per acre and in which root decay was so advanced that the plants were removed by the end of August.

(6) The fact that the present average yield of 56.84 tons per acre is the highest recorded since the houses were built.

Year after year, the results repeat themselves with an uncanny regularity, so much so that it now seems obvious that a great deal of the root troubles which cause lack of uniformity in the crop and a general reduction in crop yield is due to the soil temperature being too low during the early stages of growth.

It will be remembered also, that when Houses 7 to 10 were erected in 1923, it was decided to investigate over a period of years the causes which underlie the falling-off in crop yield which occurs gradually as the years pass, and if possible to devise means whereby the yield can be raised to the first or second years' standard.

It was found that the addition of materials such as grass cuttings, straw and peat increased the yield considerably but the original yield has not been equalled or surpassed until the present season. Actually the weight of 56.84 tons per acre obtained this year is higher than the original yield of 53.1 tons per acre.

This result opens a new field of investigation which may yield important results.

This year's experiments have also confirmed the results of last year which suggested that soil heating may ultimately replace soil sterilization to some extent, because the "soil sickness" which was obvious in House 8 during 1933, disappeared completely this year, when the soil was heated.

Some slight alteration must be made in previous recommendations because it has been found that soil temperatures of 70°F. at planting time tend to a too rapid growth at first. It is now suggested that the temperature of the soil should be increased to 65°F. at planting, and then be raised to 70°F. after the first truss has set and later to 75°F. or 80°F. after the second truss has set. Usually it is sufficient to heat the soil for 12 weeks only, calculated from the date of planting.

It has often been asked if it is necessary to heat the air of a glasshouse, when the soil is being heated artificially and to decide this question, an experiment was arranged in House 6, Chamber No. 6.

The soil was heated electrically by means of buried cables, the temperature one inch below the surface being kept at 80°F. The hot water system was cut off to prevent any heating of the air. Although the crop was not planted until the second week in March and the weather was unusually mild the growth was adversely affected. The stems were stunted and hard, the leaves were thick and somewhat small, while the flower trusses were imperfect. No fruit formed on the bottom truss and only a few on the second truss. The crop was much later than that of the adjoining Chamber No. 5 and a final weight of 37.32 tons per acre compared unfavourably with the control of 48 tons per acre.

It is obvious, therefore, that soil heating cannot replace the process of heating the air.

(g) A new method of steam sterilization.

The process of sterilizing soil by steam is so widely practised to-day that it is not surprising that methods which once seemed completely satisfactory are being superceded by those which are even more efficient and easy to work.

With the older methods of trays, grids and spikes, it is not always easy to apply the heat to every portion of the soil, owing to obstructions in the form of concrete foundations holding stay irons, and "dollies" for posts and pipes. Consequently it has not been unusual to find many small areas in the houses where diseases persist, and from which they spread rapidly to adjacent areas.

The new device overcomes the difficulties to a considerable extent, because it is composed of pipes which are laid in position separately and then joined together prior to turning on the steam.

The method was devised by Mr. J. Harnett of Hoddesdon to whom our grateful thanks are due for permission to publish details.

The apparatus consists of a number of hollow pipes with an internal diameter of $1\frac{1}{4}$ inches. These should be 6 to 8 feet long. One end of the pipe is closed by means of an iron plug, the other is fitted with an elbow and connected to a similar pipe 2 feet in length, which during steaming stands up vertically in the soil.

The horizontal pipe is perforated with $\frac{1}{8}$ -inch holes placed 5 inches apart, there being one line of holes on each side, slightly towards the bottom of the pipe.

The first hole is placed as near as possible to the iron plug and the last hole close to the elbow. The top of the vertical pipe is fitted with a screw and nut to make a good joint with the steam connection.

Four of these pipes are joined together by a suitable connection which in turn is coupled to a steam hose joined to the steam main. The connections between the individual steaming tubes buried in the soil and the metal collectors are composed of flexible metal tubing.

In a tomato house the application is simple. A trench is dug out 18 inches deep and 20 inches wide along one side of the house, the soil being taken to the place where steaming finishes so that the final trench may be filled up. To save labour the soil from the trench may be spread over the house, and the final trench filled up by taking a little soil from the surface of the last house. The bottom of the trench is broken up with a fork near the end of the house and a single pipe is placed on the bottom of the trench 10 inches away from the wall foundations. The soil is then dug out from the ground at the side of the trench and used for covering the pipe. In this way 7 feet of the first trench is filled and another trench 7 feet long, 18 inches deep and 20 inches wide is opened at the side of it. The bottom is again forked up and the second pipe laid in position 20 inches away from the first. This is covered like the first and a third trench opened to receive the third pipe. The work continues until five pipes are laid into position. Four are then connected together and the steam is turned on after covering the surface of the soil with heavy canvas, tarpaulin or old sacks. It will be noted that the fifth pipe is not connected up with the others, but it should always be placed in position for it prevents the need for putting boards down to prevent the soil from falling away. While the first four pipes are in use, another four are being placed in position ready for steaming after the first batch. If the boiler is sufficiently powerful the above arrangement can be duplicated, otherwise it is most convenient to work backwards down the house steaming a strip sufficiently wide to take eight pipes. When this is finished there will be an open trench on the outside of the steamed strip and steaming begins again at the top of the house.

When steaming is finished with the first set of pipes, they are disconnected and the second four are connected to receive steam. The work continues by pulling back the first set of pipes, a simple matter for they have been disconnected and are free to be moved singly. Attention is first given to the pipe which has the long open trench behind it. The bottom of the trench is forked up and one worker takes hold of the vertical pipe sticking out of the soil (using cloths to protect the hands for it is hot) and pulls it straight back into the trench behind. No other assistance is required unless it is unusually firmly fixed, when a second worker may exert additional power by pulling on the pipe with a drag-hook. When the pipe is in position, the end should come to within 6 inches of the spot where the back of the pipe was previously, but the measurement need only be approximate for a steaming temperature is obtained as far as 10 inches in front of and behind each pipe.

The first pipe is covered with soil from the side and a second trench opened in this way. The second pipe is pulled back into this trench and covered, after which the third pipe is pulled back and so on.

At each steaming, the area covered is about 7 feet by 7 feet and a sterilizing temperature is obtained to a depth of at least 2 feet.

The steaming time must vary with the type of soil and the degree of wetness, but in the Experimental Station soil steam was passed for twenty-five minutes to raise the soil temperature to 212°F., and was continued for another ten minutes, making thirty-five minutes for each set of pipes.

The apparatus is particularly useful in cucumber houses, but it is advisable to use short pipes and a greater number owing to the width of the beds.

In this case the centre of the house is left unsterilized, the pipes being laid in the old borders and at right angles to the length of the house. It is not easy to steam a cucumber house by the old methods owing to the two pipes on each side of the house being relatively close together, and numerous obstructions, but the new method makes it relatively simple.

The steaming pipes are made sufficiently long so that when they are passed under the two hot water pipes from the path side they extend from a point immediately beneath the centre of the gutter to a point in the path 12 inches away from the inside hot water pipe.

During the process of steaming, a trench 18 inches deep and 20 inches wide is taken out parallel to the end of the house, extending from gutter to path sufficiently long to take the steaming pipe. After forking up the bottom, the pipe is laid in position and covered with soil obtained by opening up another similar trench at the side of and parallel to the first. The second pipe is placed 18 inches to 20 inches away from the first, and so on until four pipes have been buried. Soil is then dug out from the path and spread over the border prior to steaming. This process is repeated in the adjacent border of the next house, so that four pipes in one house and four pipes in the other are placed opposite each other, with the ends of the pipes almost touching. The eight pipes are connected up in such a way that steam passes through all at the same time. This method is better than steaming each border separately for less heat is wasted. While steam is being passed through the first set, a second set of pipes is being placed in position and so on. The pipes are easily removed for they are merely pulled back out of the soil towards the centre of the house.

The cost of this method, £150 per acre for tomatoes, compares favourably with other methods, and the method of placing the pipes singly in position permits satisfactory heating of all concrete foundations, etc.

Another advantage is that the work is not arduous. Men who have worked this after the older methods claim that it is child's play in comparison. The pipes are pulled out of the soil and placed in position with so little effort that the tendency to step on the sterilized soil to get the feet in a better position for extracting the apparatus is overcome.

It is a method which can be recommended with every confidence to the commercial grower.

2. Cucumbers.

The cucumber investigations were mainly concerned with the question of warming the beds by artificial means. The results are given in Table 7.

In House C, beds on the East side were warmed by means of the old fashioned bed-pipe. This was a pipe with an internal diameter of 2 inches connected to the flow of the ordinary heating system at one end and a return pipe at the other. Satisfactory warming of the beds was not achieved, and the yield was not affected.

In House D, the beds of two plots were heated by passing an electric current through galvanised wires stretched beneath them. An average bed temperature of 90°F. was maintained throughout the season, but again the crop was not increased.

Table 7.

Variety—"Butcher's Disease Resister."

House	Plot	Treatment	Crop yield in lbs. per plant							Total tons per acre	Total flats per foot	
			March	April	May	June	July	Aug.	Sept.			Total
C	1	Beds heated by 2" bed pipe ...	0.44	12.67	14.14	10.40	11.31	3.48	—	52.44	78.66	1.62
	2	" " " " ...	0.21	11.13	14.44	11.71	9.86	5.26	—	52.61	78.92	1.63
	3	Unheated beds... ..	1.32	12.17	14.26	11.73	9.48	4.76	—	53.72	80.08	1.66
	4	" " " " ...	0.61	13.36	13.23	10.99	10.51	2.33	—	51.03	76.55	1.58
D	2	Control bed : unheated	0.80	17.15	14.54	11.67	11.11	6.51	1.47	63.25	94.88	1.95
	4	" " " " ...	1.14	17.06	14.22	12.06	11.38	6.08	2.88	64.82	97.23	2.01
	3	Beds heated : 90° F. ...	0.94	16.65	15.00	12.23	12.22	8.23	1.76	67.03	100.55	2.07
	5	" " " " ...	0.92	16.19	13.60	12.59	12.12	6.85	2.13	64.40	96.60	2.00
E	4	Control bed : unheated	1.25	16.28	15.46	11.68	10.31	6.76	3.34	65.08	97.62	2.01
	3	Beds heated : 80° F. ...	1.23	15.94	14.37	11.37	9.43	5.24	0.84	58.42	87.78	1.81
	7	" " " " ...	0.50	15.21	13.23	10.31	11.60	6.39	—	57.24	85.86	1.78
	5	Control : base not sterilized ...	1.54	14.59	12.54	9.96	5.82	1.57	—	46.02	68.97	1.39
F	6	Bed heated 80° F. ...	1.21	13.98	12.84	11.75	10.09	3.89	0.51	54.27	81.41	1.68
	1	Beds heated : 85° F. ...	1.20	14.00	14.54	11.06	13.04	6.64	3.57	64.05	96.08	1.98
	2	" " " " ...	0.95	14.66	13.05	12.04	10.77	4.88	3.03	59.38	89.07	1.83
	3	" " " " ...	0.87	13.52	12.42	11.32	10.07	5.30	2.38	55.88	83.82	1.73
	4	Control beds : unheated	1.18	17.68	13.83	13.25	11.90	4.80	0.72	63.36	95.04	1.96
	5	" " " " ...	1.00	15.76	13.58	11.17	11.34	5.07	1.30	59.22	88.83	1.83
	6	" " " " ...	1.19	15.17	13.13	11.91	11.35	5.23	1.96	59.94	89.91	1.85

In Houses E and F, certain beds were heated by circulating hot water in two 1 inch pipes buried underneath. Bed temperatures of 80°F. and 85°F. were maintained. Except in one case the higher soil temperatures did not give the increased yields anticipated. The exceptions were Plots 5 and 6 in House E. The ground under these beds has never been sterilized and the higher bed temperature gave an increased crop yield of 22%. These plots have always shewn a big increase in crop yield as the result of warming the beds.

The general failure to increase the yield of cucumbers picked from the plants by raising the bed temperature is difficult to explain, for during previous experiments a definite increase has been obtained each year.

The natural bed temperature has this year been approximately 75°F., which is five degrees higher than usual, and the increased temperature may not have been sufficient to affect the crop. Also, 1934 was a good cucumber season. The weather conditions were favourable to root development and a healthy condition of the plants, and therefore a warm soil which invariably assists root development may have been unnecessary.

Further, for the first time on a large scale, the heated beds were kept at a constant temperature throughout the twenty-four hours, by thermostatic control. In previous experiments the beds were heated at night only and were allowed to cool during the day. This may have affected the results and experiments have been arranged for 1935, which should decide this point.

Work has also been commenced in connection with the improvement of existing varieties, and the prolific "Butchers' Disease Resister" has been crossed with "Delicacy," a variety which although less prolific than the commercial type possesses a particularly good shape. The F1 generation will be grown in 1935.

3. Lettuce.

Two crops of Cheshunt Early Giant lettuce were grown during the autumn and winter of 1933—34.

The autumn crop was sown on September 14th, planted in the houses on October 5th, and marketed before Christmas. The average weight of the heads was 5 ounces, and excellent prices were obtained.

The second crop was planted during the first week in December, but a month of almost continuous fog seriously affected the crop and delayed maturity, so that marketing was not finished until the beginning of March. The individual heads averaged 7 ounces each, some weighing 8 ounces,

The quantity of foreign lettuce which is found in Covent Garden at certain times of the year is evidently due to some extent to the absence of an adequate supply of really good home-grown produce if the following experience can be taken as a guide.

In February, 1934, the first consignment of Cheshunt Early Giant lettuce, eighty-two crates, each holding two dozen heads National Mark quality, was sent from the Station to Covent Garden on February 23rd. It realised an average price of 4·7/- per crate, half being sold on the 24th and half on the 26th.

A second consignment was sold on the 27th and 28th at an average price of 4·2/-, and in view of the low prices a visit was made to Covent Garden. It was found that the market was filled with crates of Spanish lettuce, selling for 5/- to 6/- per crate. This lettuce was a large coarse sample of which less than half of each head was fit for salad making, and even this portion was extremely tough. No more heads were cut until March 5th when the salesman asked for another consignment. This sold for 5·6/- per crate, and it was reported that this tender well-hearted English lettuce had created a good demand. Later consignments sold for an average price of between 6·5/- and 7/- per crate up to the end of the crop, and were actually realising higher prices than the large Spanish lettuce.

It would seem, therefore, that Cheshunt Early Giant lettuce can be the means of reducing the value of imported lettuce on the home market and so help towards reducing the imports of this vegetable.

During 1934 a seed crop was grown in Italy through the kindness of Mr. Ceccato, of the Italian Legation in London, and the late Professor Briganti, of Naples. Unfortunately unusual weather conditions, including torrential rainfall and fog, ruined the crop, and only 1 pound of seed was received to supply growers' orders of over 40 pounds. This was a great disappointment for it was only possible to send a small quantity of seed to each applicant, but it is anticipated that a good supply of seed will be ready by next September.

4. Cold Frames.

Of recent years, particularly since duties were placed on imported vegetables, interest in early salad production has increased greatly and numerous inquiries have been received at the station concerning the cultivation of early

vegetables under frames, cloches, etc. Consequently it was decided to develop experiments in connection with early work under cold frames.

The equipment consists of eight rows of Dutch lights, 24 lights in each row, and three rows of French lights. The Dutch light consists of a single pane of glass 56 in. $\times$ 28 $\frac{3}{4}$ in. inserted in a wooden frame 59 in. $\times$ 31 $\frac{1}{4}$ in. In some cases the woodwork was painted, and in others treated by immersion for 48 hours in a 10% solution of copper sulphate and then in a 10% mixture of lime in water, the object being to compare the preserving value of the two treatments. The French lights are 53 inches long and 51 inches wide. The frame work is made of 2 inch by 2 inch deal and the three sash bars consist of "T" irons which do not give as much shade as wooden bars.

The Dutch lights possess a great advantage over the French types for having no sash bars they transmit the maximum amount of light, and further, the condensation water which forms on the glass runs down to the bottom of the pane and thence to the ground, whereas in the French lights, the drip of water which falls from the bottom of each pane on to the plants is apt to encourage *Botrytis*.

The investigations were started by growing carrots and lettuce in the frames following the best methods of commercial practice. In this respect, valuable assistance was rendered by Mr. F. A. Secrett to whom our grateful thanks are due.

The experience gained during the past two seasons has been most valuable, for the difficulties encountered have helped considerably in suggesting future experiments.

The work has already shewn the need for careful selection of varieties, and the importance of soil type in relation to cultivation in frames.

Experiments with soil heating in connection with frame work were commenced, using the same type of apparatus as in the tomato experiments. The first difficulty encountered was that of preventing the soil from drying out too rapidly as the result of the underground heating, and in many soils some system of underground irrigation will be necessary in addition to the heating installation. As might be expected the higher soil temperatures increased considerably the rate of growth of lettuce and carrots.

Much work is necessary before definite advice can be offered to growers, but soil temperatures higher than 65°F. prevent satisfactory hearting of the lettuce. The experiments will be continued.

2. Mycological Investigations.

Diseases brought to the Station and not previously reported are listed below:—

Host	Disease	Cause
Antirrhinum ...	Rust ...	<i>Puccinia antirrhini</i>
Aralea moseri ...	Root knot ...	<i>Heterodera marioni</i>
Arum ...	Spotted Wilt ...	<i>Virus</i>
Calceolaria ...	Spotted Wilt ...	<i>Virus</i>
Carnation ...	Smut ...	<i>Ustilago violacea</i>
Carnation ...	Witches Broom ...	—
Cineraria ...	Rust ...	<i>Coleosporium senecionis</i>
Cucumber ...	Fruit rot ...	<i>Bacillus carotovorus</i>
Cyclamen ...	Root knot ...	<i>Heterodera marioni</i>
Erica hiemalis ...	Wilt ...	<i>Phytophthora sp.</i>
Hippeastrum ...	Spotted wilt ...	<i>Virus</i>
Mushroom ...	Disease of beds ...	<i>Xylaria vaporaria</i>
Phlox ...	Leaf eelworm ...	<i>Anguillulina dipsaci</i>
Primula obconica ...	Rot ...	<i>Phytophthora sp.</i>
Schizanthus ...	Spotted Wilt ...	<i>Virus</i>
Zinnia ...	Flower rot ...	<i>Botrytis cinerea</i>

1. Leafy Gall of the Chrysanthemum.

P. H. WILLIAMS.

The investigations on Leafy Gall of the Chrysanthemum have been continued.

Inoculation Experiments.

A bacterium resembling *Bacterium tumefaciens* was isolated from galls in 1932 and again in 1933. In both years attempts were made to produce the disease artificially by inoculating the soil in which Chrysanthemums were growing with cultures of this organism. In neither year was conclusive evidence of infection obtained. The experiment was therefore repeated in 1934.

The method employed was described in the Nineteenth Annual Report for 1933. The periodical inoculations with a mixed culture of five strains of the organism were continued until December 11th, and the plants received 15 treatments in all. The inoculated and control plants were kept at opposite ends of a large chamber, which had been newly painted and fitted with new staging. No other Chrysanthemums were grown in this chamber and, therefore, the chances of contamination were greatly reduced.

Very little disease appeared in either the inoculated or control plants until the end of December. The experiment ended on January 2nd, 1935, 38·0% of the inoculated plants

had then become diseased compared with 47·9% of the controls. This experiment suggests that the disease is not caused by the organism which was isolated from the galls.

When this bacterium is inoculated into the stems of Chrysanthemum and Tomato plants near the growing point, small swellings are frequently produced. These swellings were at first regarded as evidence of the pathogenicity of the organism. Subsequent inoculations, however, have shewn that it is difficult to draw any real distinction between them and swellings produced by wounding. It is probable, therefore, that this organism is a saprophyte closely allied to *B. tumefaciens*.

Contaminated Soil.

In 1933 and 1934, experiments were made to determine if the soil can be a source of infection. The soil from pots in which diseased plants had been grown was used for propagating and potting. To increase the amount of contamination a number of galls were broken up and mixed with it. The control plants were propagated in sterilized sand and grown in baked compost. The variety used was Balcombe Beauty. The results are shewn in Table I.

Table I.
Effect of contaminated soil.

		Percentage Infection.	
		1933	1934
Contaminated soil	...	76·3	73·4
Sterilised soil	...	78·4	85·4

In a second experiment in 1933, plants were potted in contaminated soil after propagating in sterilized sand: 30·4% became diseased as against 25·9% in baked soil.

From these experiments it appears that the soil is not a source of infection. Soil which has been used for growing Chrysanthemums may, however, contain other parasites such as *Verticillium* and ellworm, and should not be used again unless it has been sterilized.

Control.

In the Nineteenth Annual Report it was suggested that it might be possible to reduce the amount of disease by propagating only from clean stock.

Reports from growers indicate that this has been done in certain cases. Experiments carried out during the year, however, suggest that this process may not be an easy one and further work will be necessary before any recommendations can be made.

2. The Sterilization of Lettuce Seed.

H. L. WHITE.

The task of finding a sterilizing agent more suitable for lettuce seed than those in common use for cereals and other crops, which was commenced in 1933, was completed in 1934.

From the results of the 1933 trials, calcium hypochlorite, commonly known as bleaching powder, was selected as the most promising treatment on the following grounds:—

(1) Only a small percentage—less than 7%—of seeds so treated had failed to germinate in comparison with untreated seeds.

(2) The germination of treated seeds was not retarded and the seedlings all developed normally in contrast to treatments by mercury and copper preparations and formalin, which were followed by retarded germination and a percentage of abnormal seedlings clearly suffering from metal and other poisoning.

(3) Gaseous treatment is preferable in that irregularities in the seed coat may escape contact with sterilizing agents applied in the form of liquids and dusts.

First set of trials—29/1/34.

Triplicate samples of Golden Ball, of about thirty seeds each, were treated for periods ranging from three minutes to forty-eight hours, and germinated in Petri dishes on a thin layer of agar, in order to shew if the seeds were sterile. In addition to 1933 seed, 1932 seed, that might be expected to possess less vigour, formed a parallel series. Table 1 gives the summarized results.

Table 1.

Time of Treatment.	% Germination.				Number of Petri dishes (6 treated) in which all the seeds were sterile.	
	1932 seed.		1933 seed.			
3 minutes	...	32	...	28	...	1
7 "	...	32	...	55	...	1
15 "	...	42	...	52	...	2
30 "	...	29	...	48	...	3
1 hour	...	51	...	54	...	4
2 hours	...	67	...	65	...	6
4 "	...	60	...	50	...	3
8 "	...	46	...	61	...	4
12 "	...	68	...	57	...	4
24 "	...	22	...	65	...	4
48 "	...	29	...	57	...	4

The information provided by this set of trials was as follows:—

(1) A sterile sample may be obtained in as short a time as three minutes, but fifteen minutes should be taken as the minimum time required to effect reliable sterilization (at 14°C, temperature of treatment), for after this period 90% of the seeds treated were clean.

(2) An increase in the time of treatment from three minutes to twelve hours was associated with an increase in capacity of germination independent of sterilization, for this was practically complete at all periods above fifteen minutes. This rising trend of germination capacity with increase in period of treatment was not repeated under warmer conditions, and it is believed that low temperature was limiting the rate of imbibition by the seed so that longer periods of "pre-soaking" improved the germination capacity.

(3) Germination was not impaired by any period of treatment save those for twenty-four hours and forty-eight hours (1932 seed only). Thus even if the maximum period tolerated is only twelve hours, ample margin of safety is provided by the method, for reliable sterilization was effected in as short a time as fifteen minutes.

Second set of trials—12/2/34.

Triplicate samples of Golden Ball (1932 and 1933 seed) were treated for periods ranging from fifteen minutes to ninety-six hours. As the previous trials had shewn sterilization to be satisfactory after fifteen minutes, and it was considered possible that the agar might interfere with germination, the seed was germinated upon moist filter paper. Very good germination was obtained, that of the untreated samples being 89% (1933 seed) and 90% (1932 seed). Thus the final germination capacity of 1932 and 1933 seed did not differ, but the greater vigour of the 1933 seed was shewn by earlier germination, counts at the end of twenty-four hours giving the following values:—

1932	51	} 43% germination.	1933	57	} 55% germination.
seed.	43		seed.	51	
	36			58	

Sterilization was carried out in small glass tubes, but insufficient were available for all periods simultaneously. Those from fifteen minutes to twelve hours inclusive are strictly comparable, but treatments for longer periods were started four hours later with tubes released from the shorter completed periods. The same preparation of hypochlorite was used for all treatments.

The results are summarized in Table 2. The differential effects of the treatments upon (1) acceleration and retardation of germination, (2) 1932 and 1933 seed, and (3) immediate use of the sterilizing agent as contrasted with leaving for four hours before use, are brought out by the germination counts at the end of the first twenty-four hours after treatment.

Table 2.

Time of Treatment.	First day's Germination %.				Final Germination %.			
	1932 seed.		1933 seed.		1932 seed		1933 seed.	
15 minutes	...	45	...	60	...	88	...	84
30 "	...	58	...	54	...	88	...	87
1 hour ...	...	57	...	70	...	90	...	95
2 hours	...	50	...	76	...	90	...	91
4 "	...	40	...	74	...	92	...	88
8 "	...	5	...	23	...	91	...	89
12 "	...	1	...	9	...	86	...	89
24 "	...	38	...	81	...	91	...	92
48 "	...	23	...	84	...	87	...	94
72 "	...	21	...	76	...	84	...	90
96 "	...	5	...	55	...	60	...	92

Table 2 shews that

(1) The final germination percentage of 1933 seed has been unaffected by treatments for as long a period as four days, that of 1932 seed, of less vigour, for one and possibly two days. (If fresh hypochlorite had been used these times might be shortened.)

(2) A retarding effect upon germination is apparent for periods above four hours (1933 seed) and one hour (1932 seed).

(3) With weaker hypochlorite germination is not retarded after periods of treatment less than 48 hours (1933 seed), and is even accelerated, for the initial day's germination after

treatment for this period is $\left. \begin{array}{l} 88 \\ 83 \\ 82 \end{array} \right\} 84\%$ for treated seed and

$\left. \begin{array}{l} 57 \\ 51 \\ 58 \end{array} \right\} 55\%$ for untreated seed. This might be due rather to the

effects of "pre-soaking" than to specific sterilization treatment. In contrast the germination of the 1932 seed is retarded after treatment for the same period giving initial day's

germination of $\left. \begin{array}{l} 38 \\ 20 \\ 11 \end{array} \right\} 23\%$ as against $\left. \begin{array}{l} 51 \\ 43 \\ 36 \end{array} \right\} 43\%$ of untreated seed.

Sterilization clearly exerts a differential effect upon seed samples of the same varietal constitution, but differing in vigour. Treatments that leave unharmed seed of strong constitution may be unsafe to apply to "weak" seed.

Third set of trials—11/4/34.

In these trials 1933 seed, treated for periods ranging from three minutes to seventy-two hours, was divided into two parallel series, one being germinated on filter paper and the other sown in the usual commercial manner in boxes. In order to eliminate the effect of "pre-soaking," unsterilized seed samples were soaked in distilled water for periods corresponding to those of the sterilization treatment.

Seed germinated in Petri dishes.

The percentage relation of the germination of the sterilized to soaked seed at the end of twenty-four hours, together with the final germination percentages, is shewn in Table 3. That nine of the ten sterilized samples shew acceleration of germination and suggests the possibility of an effect of hypochlorite treatment upon the breaking of seed dormancy, independent of bactericidal action and the longer period available for imbibition in comparison with unsoaked seed. There was also a retarding effect upon germination at periods of four, eight, and twelve hours that affected both soaked and sterilized seed. In an attempt to ascertain the cause of this seeds were germinated after soaking in copper-distilled water, glass-distilled water, tap water, weak hydrogen peroxide, etc. The results are not sufficiently conclusive to be worthy of record.

The mean germination percentage of the sterilized samples 86.3% compares favourably with the 88.6% of the soaked samples, and demonstrates that the treatment is harmless though applied for periods many times as long as that necessary for efficient sterilization.

Seed sown in boxes.

In boxes, the relation between the sterilized and soaked samples remained essentially the same as in Petri dishes. For ten out of twelve periods of treatment the percentage germination of the sterilized seed was higher, four days after sowing, than that of the soaked seed. The final percentage germination was not reduced below that of the soaked seed save after long periods of treatment of forty-eight and seventy-two hours.

Table 3.

Time of Treatment.	Seed germinated in petri-dishes.				Seed sown in boxes.			
	1st day's germination %.		% final germination.		% germination after 4 days.		% final germination.	
	Sterilized	Soaked	Sterilized	Soaked	Sterilized	Soaked	Sterilized	Soaked
3 mins....	49	49	85	91	39	30	84	85
7 „ ...	58	47	85	95	47	34	91	77
15 „ ...	51	48	87	88	44	38	89	71
30 „ ...	55	47	87	86	20	26	85	83
1 hour ...	46	42	85	87	25	36	86	86
2 „ ...	47	45	89	92	31	27	96	78
4 „ ...	48	27	81	81	33	31	96	80
8 „ ...	9	7	90	84	29	19	89	90
12 „ ...	—	—	87	90	31	6	96	88
24 „ ...	50	16	90	91	49	18	93	85
48 „ ...	40	20	83	90	29	27	78	89
72 „ ...	—	—	77	77	18	2	76	96

Method recommended for the sterilization of lettuce seed.

The method used, believed to have been originally introduced by Wilson*, consists of adding calcium hypochlorite (usually known as bleaching powder and procurable from any chemist) to distilled water at the rate of 5 gms. per 70 cc. (or roughly 11½ ounces per gallon), stirring, leaving for five minutes to settle, decanting, and using immediately. The original volume should be calculated so as to allow of the rejection of a third of the liquid during decantation, sufficient being left to just cover the seed. The latter may be placed in a glass bottle, which can be corked and shaken periodically to overcome the tendency of the seed to float on the surface. Four to eight hours is recommended as a suitable period, but any period between fifteen minutes and twenty-four hours should give satisfactory results. Below fifteen minutes sterilization may be incomplete and above twenty-four hours there is a risk of seed injury. Washing the seed after treatment reduces the risk of seed injury. Preparations of bleaching powder differ markedly in their chemical activity and the sterilization of large quantities of seed should be prefaced by observation of its effect on a small sample, which may be germinated on moist blotting paper.

* Amer. Journ. of Bot., 1915.

3. Vegetable Diseases.

H. L. WHITE.

During the year a number of inoculations have been made on Lettuce and Runner Bean with fungi and bacteria isolated in association with root rots of these plants. The results serve to emphasise the desirability of carrying out this work in such a way as to disclose the conditions predisposing the plant to attack, for in many cases these appear to be the essential factors in determining the appearance of the disease. Moreover the length of time that may elapse between the inoculation of plants grown under the cool conditions suitable for Lettuce and Bean and the appearance of disease symptoms tends to be disadvantageous to the nurseryman whose crop may be finished before he can be supplied with definite advice. As a preliminary step towards overcoming these difficulties an experimental chamber is being constructed, in which the plant's environment will be artificially controlled.

Inoculations with a number of fungi isolated in association with the rhubarb disease reported in 1933 have yielded negative results. The results of similar inoculations with bacteria are not yet to hand.

4. Carnation Diseases.

H. L. WHITE.

The study of carnation diseases, interrupted by the absence of the writer from the station, has been resumed.

Survey of a nursery upon which experiments had been conducted in 1926-7 showed that a disease—apparently a true vascular wilt—had become very prominent in 1934, whereas formerly it either did not exist there or else caused so little damage that it had not been noted by the writer. The isolation of the same fungus from plants sent by nurserymen to this station and examined by the writer suggested that the disease was also of considerable importance upon other nurseries.

In response to appeals from nurserymen the investigation of three problems was undertaken during the year:—

(1) The cause of the disease.

(2) Whether the disease could be transmitted from crop to crop in the cuttings.

(3) If it was safe to replace the carnation crop in badly infected blocks of glasshouses by tomatoes.

Cause of the disease.

Isolation work.

From a typical badly affected bed thirty wilting plants were selected at random, divided into three groups of ten, and nearly 400 isolations made by six different methods:—

- (a) Transfer to slopes of nutrient agar of portions of diseased stems between the collar and the topmost main limb.
- (b) Transfer to slopes of nutrient agar of portions of woody tissue taken to a distance of not less than 3 feet above the main limbs, at least six isolations at 6 inch intervals being made.
- (c) From similar material as in (b) 1 inch sections cut at 3.5 inch intervals, surface sterilized and placed on plates of nutrient agar.
- (d) Outgrowths from similar material as in (b), when placed in a moist chamber.
- (e) As (d) but the same portion of the plant used as in (a).
- (f) Roots, after surface sterilization, placed on nutrient agar.

The results are summarised as follows:—

(1) Over 80% of the isolations made by method (b) yielded the same fungus, at least two cultures, free from any other organism, being obtained from each of the ten plants used. Although the topmost isolation was made from apparently healthy wood, this fungus was present in all cases but one, shewing that its growth might extend for 3—4 feet up the stem before wilt occurred and that the limit of the infection was very difficult, if not impossible, to detect with the naked eye. The fungus was found to be identical with a type culture of *Verticillium cinerescens*, provided by the Bureau voor Schimmelcultures, Baarn. The sixty-one isolates obtained by this method contained no fungus of the *Fusarium* group.

(2) The incidence of *Verticillium cinerescens* in isolates obtained from similar material but by method (c) fell to 16%. In contrast to isolations by method (b) the *Fusarium* group was strongly represented. That these fungi were growing in the tissue external to the wood was demonstrated by:—

- (1) Their absence from isolations made directly from the wood.

- (2) The occurrence of sterile plates, showing that the method of surface sterilization used had been efficient.
- (3) A tendency for adjacent isolations from the same stem to yield the same species.

Apparently there are a number of *Fusaria* that may infect superficially carnation stems and grow, presumably in the cortex, for distances as far apart as 2 feet.

(3) Of a series of eighty-one isolates from roots, *Verticillium cinerescens* was responsible for 6%. In a second series of eighty-one isolates *Verticillium* was not found. *Fusaria*, the commonest probably being *F. acuminatum* and *F. culmorum*, formed nearly half of the total organisms obtained. 6% only of roots used were clean. The isolation from the seven main roots of one plant of six cultures (the remaining root being clean) of *F. culmorum*, no other organisms being detected, may be noted.

(4) Isolations from the region of the collar yielded mainly *Fusaria*.

The results of the isolation work suggested strongly that *Verticillium cinerescens* was the cause of the disease for it was obtained from 100% of diseased plants, provided that the method of isolation did not permit its presence to be obscured by more rapidly growing fungi. The second most common fungus *F. culmorum*, was obtained from seven out of every ten plants examined.

Preliminary inoculation work.

Preliminary inoculations consisted of pricking the following fungi into the bases of young carnation shoots.

(1) *Verticillium cinerescens*.

(2) *Fusarium culmorum* (a strain isolated from carnation plants in November, 1925, and since kept in culture at this station).

(3) *Fusarium* (section *Elegans*), kindly supplied by Mr. G. M. Wickens.

The results are shewn in Table 1.

F. culmorum was responsible for a rapid wilt characterized by rotting of all the tissues of the stem. *F. (section Elegans)* and *V. cinerescens* by a slower wilt, associated with extensive vascular infection. The fungi were readily re-isolated at some distance from the points of inoculation.

Table 1.

Inoculum	Date of inoculation	Number of inoculations		Mean date of wilt	st. dev. of mean date	Apparent length of infected stem
		Number of inoculations	Number of inoculated shoots showing wilt.			
<i>V. cinerescens</i>	30/8/34	7	7	17/11/34 $\pm$ 6 days		29.8 cms. $\pm$ 5.4 st. dev.
<i>F. culmorum</i>	—	6	5	11/9/34 $\pm$ 3 „		3.5 „ $\pm$ 0.3 „
<i>F. (section Elegans)</i>	—	7	6	14/11/34 $\pm$ 7 „		22.3 „ $\pm$ 4.4 „
Controls ...	—	3	0	—		—

This experiment, in conjunction with the isolation work, leads to the conclusion that *Verticillium cinerescens* is responsible for the wilt disease which occurred on the bed under investigation.

Earlier investigations, recorded in the Annual Report of this station for 1928, and the Journal of Pomology, June, 1929, do not refer to this fungus, which, so far as the writer is aware, was not encountered in the diseased carnation beds then examined.

Transference of the disease by cuttings.

(1) Shoots, that would have been suitable for cuttings if healthy, were taken from freshly wilted plants. Isolations from the base yielded *Verticillium*. Observation has shewn that cuttings are sometimes taken by nurserymen from plants that wilt shortly afterwards.

(2) Sixty-seven cuttings from apparently healthy plants on a bed containing diseased patches were taken by a nurseryman, as if for his propagation, and handed to the writer, who cut a section from the base of each, sterilized the exterior and placed them on nutrient agar. 58% were clean, 35% contained fungi not suspected of causing wilt, and 7% fungi provisionally identified as *Verticillium cinerescens*.

(3) Seventy-two similar cuttings were supplied to the writer, who split open their base with a sterile knife, dissected out the wood with a pair of sterile tweezers over a porcelain

plate, frequently wiped with 0.1% Hg Cl_2 , and placed them on slopes of nutrient agar. The results were as follows:—

Clean cuttings	...	...	...	...	...	40%
Cuttings containing fungi not suspected of causing wilt						38%
Cuttings containing fungi provisionally identified as <i>V. cinerescens</i>	...	...	...	...	...	15%
Cuttings containing <i>Botrytis</i>	...	...	...	...	...	6%
Cuttings containing <i>Fusarium</i>	...	...	...	...	...	1%

The results suffice to shew that *Verticillium* DISEASE MAY BE TRANSFERRED FROM CROP TO CROP *via* THE CUTTINGS. It has been shewn by the isolation work that the fungus may extend several feet up the stems of plants before wilt occurs, and INTO THE BASES OF YOUNG SHOOTS NORMALLY TAKEN FOR PROPAGATION. It is difficult to see how a nurseryman could recognize, and for propagation purposes, eliminate a plant outwardly healthy yet carrying the disease in the bases of shoots suitable for propagation. There appears little doubt that contamination may be spread by normal methods of propagation, not only from a single infection centre over an entire nursery, but FROM ONE NURSERY TO ANOTHER BY MEANS OF STOCK EXCHANGED OR SOLD.

These considerations emphasize the importance of propagation from beds known to be free from disease and NOT FROM PLANTS APPARENTLY HEALTHY BUT ADJACENT TO A DISEASED PATCH. It is suggested that stock brought on to a nursery from an outside source be grown in "quarantine" houses kept for this purpose. In order to determine the stage at which a cutting carrying the fungus first shews the disease, an experiment is being carried out in which cuttings have been deliberately taken from plants adjacent to diseased areas and struck under normal commercial conditions.

Alternation of a carnation crop with tomatoes.

31/8/34. Six young tomatoes were inoculated by hypocotryl stab with *Verticillium cinerescens*.

30/11/34. Examination shewed that the infection had not spread, although the plants were under the same environmental conditions as carnation plants successfully inoculated with *Verticillium cinerescens*.

Summary.

(1) Examination of a bed of carnation plants badly affected by "wilt" shewed that the cause of the disease was a fungus *Verticillium cinerescens*.

(2) Comparative inoculations with *Verticillium cinerescens* and *Fusarium culmorum* shewed that, under the conditions of the experiment, *V. cinerescens* caused a slow wilt with extensive vascular infection, whereas *F. culmorum* caused a rapid wilt in association with rotting of all the tissues near the point of inoculation.

(3) *V. cinerescens* may, by the methods of propagation normally practised on commercial nurseries, be transferred from crop to crop *via* the cuttings, and is probably spread from one nursery to another in stock exchanged or sold.

(4) Tomatoes may safely be used as an alternative crop on carnation beds badly infected with *Verticillium cinerescens*.

5. Rose Diseases.

W. F. BEWLEY, O. B. ORCHARD, AND P. H. WILLIAMS.

The investigations of the diseases of the rose have been continued during the past season.

The copper in oil spray for the control of leaf diseases mentioned in the last annual report was submitted to severe test. Both in glasshouses and in the open it has given particularly good results against the ordinary mildew. Half the plants in the experimental rose house were sprayed at intervals of three weeks starting on March 26th, the others being left unsprayed. By June 5th the untreated plants were white with mildew, while the sprayed plants were particularly clean. The heavily infected plants were then sprayed with such good effect that the young shoots were quite clean, and were maintained in this condition by spraying another three times during the remainder of the season.

In the open, rose bushes were kept free from mildew by spraying twice during the season.

Last year this copper in oil spray gave promising results against Rust, but in the light of evidence obtained this year it has been found that the particular type of Rust used in last year's experiments was that which attacks *Rosa canina* and the seedling briars, and which, until identification is complete, will be termed *Phragmidium A*. The type which attacks *R. laxa* and the cultivated rose, here called *Phragmidium B*,

did not occur naturally at Cheshunt this year, and in consequence trials had to be conducted with roses inoculated artificially with spores of *Phragmidium B.*

This limited the scope of the work, but sufficient evidence was obtained to shew that *Phragmidium B.* is less susceptible to the copper in oil spray than was *Phragmidium A.* Stronger concentrations were necessary to prevent germination of the spores, and the spray was then liable to cause slight burning and leaf fall under some conditions which are not fully understood. Major Shelly, Dr. Deacon and Mr. Courtney Page very kindly tested this spray in their own gardens and have confirmed these results.

The spray must be modified further before it can be recommended for general use.

The question of overwintering of rose rust has been investigated by collecting large quantities of leaves of *R. canina* and *R. laxa*, heavily infected with teleutospores of the rust fungus, storing them under different conditions during the autumn and winter, and attempting to germinate them at fortnightly intervals. Due attention was paid to the effect of moisture and temperature during storage and germination. Although most of the tests were kept under observation until July, 1934, germination of the teleutospores was not observed.

During April and May regular attempts were made to infect rose plants from the teleutospores, but none were successful.

It would seem, therefore, that it is not easy to start an artificial attack of rose rust by means of the teleutospore stage, and if such occurs in nature the conditions for infection are not easy to arrange experimentally.

A more likely method of overwintering is that depending upon lesions formed on the plant during the previous growing season, which may produce masses of hibernating mycelium.

Rust has been collected from several different sources, and each sample is being tested separately upon cultivated roses and upon rose species, with a view to determining its host range. This work cannot be completed quickly, but will be continued until the required information has been collected. No attempt is being made at present to name the different strains, other than to distinguish them as *Phragmidium A.*, *Phragmidium B.*, etc.

The results so far obtained are summarised below :—

Strain.	Source.	Host.	Characteristic Features.
<i>Phragmidium A.</i>	<i>R. canina.</i>	<i>R. canina.</i>	Light yellow spore masses, and abundant yellow spots on the upper surface of leaf above each pustule.
		<i>R. laxa.</i>	Spore masses similar, but infection generally slight.
		Cultivated Rose.	No Infection as yet.
<i>Phragmidium B.</i>	<i>R. laxa.</i>	<i>R. laxa.</i>	Spore masses bright yellow. Spores very abundant, falling off readily. Yellow areas on upper surface of leaves.
		Cultivated Rose.	Infection has been obtained.
<i>Phragmidium C.</i>	Cultivated Rose.	Cultivated Rose.	Orange yellow pustules with yellow areas on upper side of the leaf. The pustule may cover the whole underside of the leaf and the spores fall off readily.
		<i>R. laxa.</i>	No infection in three tests. Roses inoculated at same time were infected.
<i>Phragmidium D.</i>	<i>R. rosga.</i>	<i>R. rugosa.</i>	The whole of the under surface of the leaf may be covered with orange yellow pustules.
		Cultivated Rose.	Reaction similar to those produced by <i>Phragmidium C.</i>
		<i>R. laxa.</i>	No infection in three tests where roses inoculated at the same time were infected.

A study is being made of the incidence of rose rust in this country, and it is apparent that while this disease is very severe in some areas, it causes but little trouble in others, and is entirely absent in certain localities. Districts liable to heavy dew formation seem to suffer badly from this disease, but there may be other factors, and information on this point will be greatly appreciated from any one who cares to communicate with the Station.

In the laboratory and experimental houses an attempt is being made to discover how infection with rust is affected by such influences as temperature, humidity and light.

It has been found that to secure infection following artificial inoculation, the plants must be kept in a moist chamber at a humidity of not less than 90% for from three

to four days. It has not been determined whether high humidities are necessary for the whole of this period, but in one case where infection was obtained on the bench in an ordinary glasshouse, it was found that the atmospheric humidity exceeded 90% for from 6—12 hours at night and fell to 40% during the day for the first ten days after inoculation. Although many experiments have been conducted it is not possible to draw any definite conclusions at this stage, and the work will be continued, but the results suggest that a certain period of higher humidity at night is essential for infection.

Infection has been obtained at temperatures between 60°F. and 70°F., and although the cardinal points have not yet been determined, it seems probable that high temperatures do not favour infection, especially when the air is dry, and also that the different strains possess different temperature requirements.

Pursuing still further the inquiries into the reasons for the death of rose trees in gardens and in glasshouses, it has been found that *Coniothyrium rosarum* is implicated in a great proportion of cases, but the facts are not fully understood.

This fungus does not seem to be a vigorous parasite, for in some bushes infected areas do not extend rapidly, whereas in others the fungus makes rapid progress through the tissues of the host.

The destructiveness of the fungus, which depends upon the rate at which it travels in the plant, depends upon a number of influences, among which are the rate at which the stock and scion become connected, and the suitability of the stock for the particular scion employed.

It is obvious that an investigation concerning the suitability of stocks is urgently required.

6. A Disease of Winter Cherry.

O. B. ORCHARD.

During the past season diseased specimens of *Solanum capsicastrum* have been received from a number of growers.

The first symptom of the disease is a slight wilting of the whole, or part of the plant, followed by total collapse in about two or three weeks. Wilting may take place at any stage of growth, for in cases under observation the disease has appeared in the seedling stage, and has continued to appear throughout the season,

The causal organism which was easily isolated proved to be a species of *Phytophthora*, probably *P. parasitica*. A number of healthy plants were inoculated with pure culture of the fungus, some at soil level where the wood was quite hard, and others in green stem wood. In the case of the green stem inoculations wilting of growth above the point of inoculation occurred in an average of ten days. Inoculation made in the main stem at soil level where the tissues are harder caused total wilting in approximately three weeks. These experiments were conducted during the early autumn, and it is possible that death of the plant would be even more rapid earlier in the year. Young seedling tomatoes in size sixty pots collapsed in three days after inoculation with the fungus.

During the past few years a number of growers have reported serious losses of the winter cherry, the damage being so serious that several have given up the cultivation of this crop. In one nursery under observation during the past season the losses have amounted to 30%.

Although not previously observed under experimental conditions, it is considered possible that *Phytophthora* *sp.* has been responsible for most of the losses suffered by growers of this crop during past years.

In view of the above results and the rapid rate at which infection may occur when the soil is contaminated growers of *Solanum capsicastrum* are advised to use only sterilised soil for the propagation and cultivation of this plant. Soil may be sterilised by steaming, by baking, or by treatment with formaldehyde. If none of these methods can be employed the soil should be saturated with a solution of Cheshunt Compound after seed has been sown, and frequent applications should be made throughout the growing season.

It must also be remembered that *Phytophthora* is often carried in the water supply unless this is obtained from deep wells or a water supply Company.

7. A Disease of Cultivated Heaths.

W. F. BEWLEY AND E. OYLER.

Introduction.

Towards the middle of June last year a serious disease of heaths, *Erica hyemalis* and *E. nivalis*, appeared on a nursery where many thousands of these plants are grown annually. The first symptoms shewed as a peculiar greying of the foliage, which does not occur on healthy plants. This was followed by wilting of the top of the plant, and finally complete withering and death.

Table 1.
Effect of Different Methods of Inoculation.

Series.	Method.	Host.	Result.
1	Branches inoculated...	<i>E. hyemalis</i> (large)	5th—9th days: 95% inoculated branches wilted.
2	Branches inoculated...	<i>E. hyemalis</i> (small)	12th day: 100% inoculated branches wilted.
3	Branches inoculated...	<i>E. nivalis</i> (small)...	7th—8th days: 100% inoculated branches wilted.
4	Branches inoculated...	<i>E. gracilis</i> (large)...	No infection.
5	Stem inoculated at soil level	<i>E. hyemalis</i> (small)	19th—22nd days: 100% plants wilted. 41st—47th days: 100% plants died.
6	Soil inoculated	<i>E. hyemalis</i> (small)	34th—48th days: leaves of main stem yellow. 62nd—65th days: 75% plants dead.
7	Sterilized ashes inoculated with mycelium on bran. Heaths placed on ashes.	<i>E. hyemalis</i> (small)	No infection yet.

Examination of the roots and stem revealed browning of the tissues, which seemed to progress upwards from the soil.

Two fungi were isolated, one a species of *Phytophthora* and the other a species of *Fusarium*.

Inoculations.

Inoculations from pure cultures of both organisms caused wilting of the small branches used for the purpose, but whereas the *Phytophthora* spread through the entire plant the injury caused by the *Fusarium* was confined to the inoculated branch.

It was assumed that the *Phytophthora* was the organism responsible for the widespread destruction of the crop, and investigation was concentrated upon this fungus.

The organism was readily re-isolated on Quaker Oat agar, proved to be identical with the original isolation, and its pathogenicity was easily proved by repeatedly inoculating healthy plants.

A series of experiments were arranged to discover how infection occurs in nature, and how it is influenced by environmental conditions.

Table 1 shews the effect of different methods of inoculation, and it will be seen that the disease can be produced easily by either inoculating the plant itself or the soil in which it is growing.

The results given in Table 2 suggest that the progress of the disease is greatly affected by temperature conditions. From these experiments it is not possible to give information with regard to the effect of actual temperatures, but it is established that the disease makes more rapid progress at cucumber house temperatures than at lower temperatures.

This is in accordance with the observed fact that in nature the disease is one which appears during the hottest part of the year.

Table 3 gives the results of inoculating other plants or parts of plants. It will be observed that the *Calceolaria* is a susceptible host.

Discussion.

The above experiments indicate that a serious disease of cultivated heaths is caused by *Phytophthora* sp. Identification is not complete, but the fungus resembles *Ph. syringæ* to some extent.

Table 2.
Effect of Different Temperatures.

Series.	Method.	Host.	Situation.	Result.	
				No. of days before wilting occurred.	No. of days before death of plant.
1	Branches inoculated	<i>E. hyemalis</i> (small)	Outside ...	15: 15% branches wilted	No death.
2	Branches inoculated	<i>E. hyemalis</i> (small)	Cool Greenhouse	14-25: 100% "	No wilting beyond inoculated branches.
3	Branches inoculated	<i>E. hyemalis</i> (small)	Chamber ...	5-10: 100% "	47: 50% plants dead.
4	Branches inoculated	<i>E. hyemalis</i> (small)	Cucumber house	4-9: 100% "	63: 50% plants dead.

Temperature Range.

Situation.		Max. ° F.	Min. ° F.	Mean ° F.
Outside	...	62.0-39.0	60.0-35.0	61.0-37.0
Cool house	...	63.0-48.0	50.0-39.0	55.0-42.0
Chamber	...	101.0-59.5	68.5-46.5	80.0-53.0
Cucumber house	...	113.0-73.0	68.0-55.0	86.0-66.0

Table 3. Inoculation of other Hosts.

Series.	Method.	Host.	Result.
1	Stems inoculated	Calceolaria	5th day: leaves above inoculation wilted. Wilt did not spread below first pair of leaves.
2	Stems inoculated	<i>Nicotiana glutinosa</i>	Galls formed on stems.
3	Stems inoculated	Tomato	No infection.
4	Fruits inoculated	Tomato	3rd—4th days: rot appeared and spread through fruits.
5	Fruits inoculated	Apple	5th day: rot appeared and spread through fruits.
6	Stems inoculated	<i>Nicotiana tabacum</i>	No infection.
7	Stems inoculated	Gloxinia	"
8	Stems inoculated	Cineraria	"
9	Stems inoculated	Begonia	"
10	Stems inoculated	Coleus	"
11	Branches inoculated	<i>Solanum capsicastrum</i>	"
12	Petioles inoculated	<i>Primula stellata</i>	"
13	Inflorescence axes and petioles inoculated	<i>Primula obconica</i>	"
14	Roots inoculated	Carrot	"
15	Tubers inoculated	Potato	"
16	Buds and stems inoculated	Lilac	"

Past experience with *Phytophthora* throws suspicions upon the water supply, the compost in the pots and the "standing out" ground. These are being examined as possible sources of infection, and it is interesting to note that *Calceolarias* were "stood out" on the same ground prior to the heaths.

A further report will be published when the investigations have been completed.

8. Virus Diseases (1).

G. C. AINSWORTH.

(a) General.

During 1934 119 enquiries were received from growers involving the examination of 137 samples of plants suspected of suffering from virus diseases. This represents an increase of 25% over the previous year's enquiries.

Two cases of mixed-virus streak of tomato (see page 63) were recorded from glasshouses, but in neither case was the source of the potato virus traced. Mixed-virus streak is not very common and was only noted once in 1933.

Damage to tomato plants at first attributed to a virus proved to be chlorate injury; chlorate weed-killer having been used without sufficient care (see also Chemical Section of this Report).

Spotted wilt was again prevalent; twenty-five outbreaks on tomato being noted. It was recorded for the first time from both Guernsey and Jersey in the Channel Islands. During the year *Hippeastrum*, *Calceolaria*, *Richardia* (Arum) and *Schizanthus* were noted as hosts of spotted wilt. A single adult specimen of *Thrips tabaci*, obtained from a diseased dahlia plant showing rather indefinite symptoms, was fed on a seedling tomato plant which developed typical spotted wilt symptoms. Later spotted wilt infected cineraria plants were obtained from the same greenhouse.

The position regarding chrysanthemums and spotted wilt is somewhat unsatisfactory. Chrysanthemums are certainly susceptible to spotted wilt. Under favourable conditions the disease manifests itself by well defined ring and line patterns on the leaves, and the virus can be mechanically transferred to tomato and other plants. Under less favourable conditions, however, diagnosis of the disease with certainty is often impossible because of the difficulty that is experienced in transferring the virus from chrysanthemum to other plants. Attempts were made during the last season to infect eleven

different varieties of chrysanthemum, but the inoculated plants differed in no way from the uninoculated controls. Although much damage to chrysanthemums attributed to spotted wilt is probably due to eel worm and various cultural defects, there is strong circumstantial evidence that spotted wilt has been introduced and spread on certain nurseries by infected chrysanthemum stocks, and for this reason chrysanthemums should be carefully watched and any suspected stocks isolated or destroyed. It is most important that cuttings should be taken only from healthy plants.

(b) A comparison of English and Canadian virus diseases of tomato.

During 1933-34 a comparison of certain English and Canadian virus diseases of tomato was made in co-operation with G. H. Berkerley, of the Laboratory of Plant Pathology, St. Catherines, Ontario, who was on a year's visit to this country, and J. Caldwell, of the Rothamsted Experimental Station. Material considered typical of the various diseases was collected in different parts of Canada, sent to this country in the dried state, and on arrival each sample was divided into three portions which were independently examined by the three collaborators. The several viruses detected were compared with standard material of this country.

The results of this comparison, which have been published elsewhere* and will not be detailed here, shewed that the commoner virus diseases of tomato are the same in both countries. Tomato mosaic, yellow tomato mosaic, and virus diseases of the streak type occur in England and Canada, though the results did suggest that mixed-virus streak occurs more frequently in Canada than in England. A third disease of the streak type, ring mosaic streak, occurs in America.

Several potato viruses were isolated from the Canadian tomato material during the course of the above investigation. In order to establish the identity of these viruses, which all appeared to be strains of the American "healthy potato virus," they were compared with each other and with standard material. As a result of this comparison, details of which have already been published,† it was concluded that all the viruses studied were strains of *potato virus X*, K. M. Smith. There was a marked difference in virulence between some of the strains of the potato virus, and it was found that the inoculation of a tomato plant with a mild strain of the virus effectively protected the plant against subsequent infection by a virulent strain.

* Ainsworth, G. C., Berkeley, G. H., and Caldwell, J., Ann. App. Biol. XXI, 4, 566-80.

† Ainsworth, G. C. *ibid*, XXI, 4, 581-87.

(c) Virus diseases of the tomato.

During the course of the investigations summarised in the previous section the various virus diseases of tomato occurring in this country were critically examined, and certain changes in nomenclature have been proposed. Brief accounts of the tomato virus diseases at present recognised in this country are given below. The name of each disease is given, synonyms (the use of which should be discontinued), the name of the causal virus, and a short description of the symptoms on tomato.

(1) Tomato mosaic.

DISEASE SYNONYMS. Ordinary or mild tomato mosaic.

VIRUS. *Tobacco virus 1*, Johnson, the cause of common tobacco mosaic.

SYMPTOMS ON TOMATO. A light green-dark green mottle of the leaves which shew a varying degree of distortion. The plant is slightly stunted but the fruit is not usually affected. There is no necrosis of stem or leaves as in streak disease. In winter the mottle is absent or very slight, but leaf distortion and stunting are more severe. The effect of this disease on a well-grown tomato plant is usually not severe though tomato mosaic is sometimes a serious trouble, especially during the propagating stages. (For further particulars of this disease see Eighteenth Annual Report, page 43.)

(2) Yellow mosaic of tomato.

DISEASE SYNONYM. Aucuba mosaic of tomato.

VIRUS. *Tobacco virus 6*, Johnson.

SYMPTOMS ON TOMATO. A light yellow mottle of the leaves which also shew some distortion, and the ripe fruit is disfigured by yellow or silver coloured patches. The plant is stunted. In winter there is marked leaf distortion and stunting, but the yellow mottle is not usually exhibited.

(3) Tomato streak.

There are several diseases of the streak type which, though in so far as symptoms on tomato are concerned may be identical, have, nevertheless, been proved to be caused by different viruses. Two of these diseases are known to occur in this country (see Eighteenth Annual Report pp. 42—45). They are:—

(a) Single-virus streak.

DISEASE SYNONYMS. Glasshouse streak and "Stripe."

VIRUS. *Tomato streak virus 1*, Ainsworth, Berkeley and Caldwell.

SYMPTOMS ON TOMATO. There are necrotic lesions (brown streaks or stripes) on the stem. The leaves and the fruit shew brown lesions and the leaves also exhibit a dark green-light green mottle with some distortion. Under certain conditions the disease manifests itself as a mottle only when it is liable to be confused with tomato mosaic.

Single-virus streak is the commonest streak disease of glasshouse grown tomatoes in this country.

(b) Mixed-virus streak.

DISEASE SYNONYMS. Experimental streak and streak.

VIRUS. A mixture of two or more viruses. Generally this mixture is a tobacco mosaic virus or *tomato streak virus 1* and a potato virus of the X type.

SYMPTOMS ON TOMATO. As for single virus streak above but a mottle only is rare.

Though single-virus streak and mixed-virus streak are difficult to distinguish on tomato, they may be easily differentiated by the reactions of other plants such as *Nicotiana glutinosa* and *Datura Stramonium*.

(4) Spotted wilt of tomato.

VIRUS. Spotted wilt or "T.S.W." virus.

SYMPTOMS ON TOMATO. The first symptoms of the disease, a bronzing and downward curling of the apical leaves, and stunting of the plant, are diagnostic. The fruit may be more or less severely disfigured by bronze or yellow coloured markings, often ring-like. (For further particulars of this disease see Eighteenth Annual Report, pp. 39—42, and Nineteenth Annual Report, pp. 54—55.)

(d) Mosaic diseases of the cucumber.*

In last year's Report (Nineteenth Annual Report, pp. 56—59), some details were given of two mosaic diseases of cucumber, "mild cucumber mosaic" and "yellow cucumber mosaic," and a third disease, "aucuba mosaic of cucumber" was mentioned. As a result of further work these three diseases have been more clearly differentiated. It is thought desirable that a disease name should, if possible, give an indication of the typical symptoms, and bearing this in mind, certain changes in name of the cucumber mosaic diseases have been proposed. Given below are the new names and the various synonyms, the names of the viruses concerned, and short descriptions of the disease symptoms on cucumber.

* For a more detailed account see Ann. Appl. Biol. XXII, No. 1, 55-67.

(1) Green-mottle Mosaic.

DISEASE SYNONYMS. Mild cucumber mosaic, green cucumber mosaic, "cucumber mosaic."

VIRUS. *Cucumber virus 3*, Ainsworth.

HOST RANGE. Cucurbitaceæ.

SYMPTOMS ON CUCUMBER. There is a dark green-light green mottle together with blistering and distortion of the leaves, and stunting of the plant. The fruit is usually unmarked. Occasional yellow flecks occur on leaves and may at times be a prominent symptom though there is never a general yellow mottle; a characteristic symptom of the two following diseases.

(2) Yellow mosaic.

DISEASE SYNONYMS. Aucuba mosaic of cucumber, "Cucumber mosaic."

VIRUS. *Cucumber virus 4*, Ainsworth.

HOST RANGE. Cucurbitaceæ.

SYMPTOMS ON CUCUMBER. The leaves shew a mottle, typically bright yellow but varying from pale yellow to nearly white, and are only slightly distorted. The plant is slightly stunted. The mottle either takes the form of few to many star-like spots, which may almost cover the whole leaf, or gives a vein-banding effect. The vein-banding may be well defined or appears as a filigree of fine lines which follow the smaller veins.

When growing conditions are less favourable the bright yellow mottle is replaced by a rather inconspicuous yellowish-green mottle when the disease is liable to be confused with green-mottle mosaic. The fruit is marked by yellow or silver coloured spots or streaks. Fruit marking is most severe at temperatures above 84°F.

(3) Yellow-mottle mosaic.

DISEASE SYNONYMS. Yellow mosaic, and the American names, common cucumber mosaic, cucurbit mosaic, and white pickle.

VIRUS. *Cucumber virus 1*, Johnson.

HOST RANGE. Cucurbitaceæ, Solanaceæ, and others.

SYMPTOMS ON CUCUMBER. A yellow mottle on all leaves developed after infection, some leaf distortion, stunting of the plant, and the fruit is usually mottled. The yellow mottle is

rather different in both colour and type from that produced by *cucumber virus 4*. It is a greenish-yellow colour and somewhat diffuse, as the green parts of the leaf yellow slightly, while the mottle of yellow mosaic is more sharply defined and varies in colour from pale yellow to silver white.

Cucumber virus 1 is able to infect the tomato giving rise to the condition known as fern leaf (see last year's Report, page 58).

(e) Cigarettes as a possible source of tomato mosaic.

It has been known for some years that cured tobacco is liable to contain viruses, and research in both America and Japan has indicated that outbreaks of virus diseases, such as tobacco or tomato mosaic, may be initiated through the use of such infected tobacco by the workers.

In order to obtain an idea of the extent to which smoking tobacco of this country is infected with viruses, twenty-six samples of tobacco as smoked by members of the Staff of this Station, including tobacco of both American and Empire origin, were tested for the presence of viruses. Twenty-one samples (twelve different brands) of cigarettes, four samples (two brands) of pipe tobacco, and one (low grade) cigar were tested. Virus was detected in twenty of the cigarette samples, two of the pipe tobacco samples (both the same brand), and in the cigar; that is, of the twenty-six samples examined only three were free from virus. In all cases but one, where the virus was not identified, the virus was that of tomato mosaic (*tobacco virus 1*).

In making the tests the various samples of tobacco were soaked in distilled water for several hours, often overnight, and tobacco plants inoculated by wiping two or three leaves with pieces of muslin moistened with the inoculum so prepared. The symptoms shewn by the infected plants were quite typical of tobacco mosaic, and the only points worth recording are that there was often less than 100% infection, only one or two of three plants becoming infected, and the incubation period was a few days longer than the normal. Both these effects indicated a low concentration of virus in the material.

These results are not without interest to the tomato grower. Tomato mosaic is always widespread, and as cigarettes frequently contain the responsible virus they are almost certainly one of the sources from which infection of

the crop arises each year. Tomato mosaic is extremely infectious by contact. The fingers of a smoker might become contaminated from the butt end of the cigarette and infect an occasional plant. The numbers of plants infected in this way, if early in the season, need be very few indeed to ensure infection of the whole crop for the disease is spread so rapidly and efficiently during the various cultural operations which necessitate handling the plants. In this connection attention is drawn to the fact that infection with mosaic is often first noted about the time of the first pruning and tying operations. It is usual to prohibit smoking by workers handling all plants used in virus disease investigations, and as this restriction has beneficial results it is probably worth a trial by growers. In conclusion it may be said that washing the hands with soap and water is an efficient means of removing virus contamination whether resulting from smoking or the handling of diseased plants.

9. Virus Diseases (2).

W. H. READ.

Soil in relation to virus diseases.

The results of previous experiments have shewn that the addition of plant-poisons to the soil increased the severity of aucuba mosaic in young tomato plants grown therein. The substances employed in these experiments were some of the commonest compounds isolated by other workers from soils of low fertility.

Virus diseases of the tomato, however, are common on all types of soil including those of high fertility, and in consequence attempts have been made to determine if there are present in some soils substances which may be responsible for the severity or possibly the annual occurrence of virus diseases of tomatoes grown in them. For this purpose soil was obtained from a nursery where aucuba mosaic of the tomato has been very prevalent for a number of years.

A preliminary test was made in which tomato plants were grown in pots containing this soil, a clay-loam and therefore unsuitable for pot culture. Some of these plants were inoculated with aucuba mosaic and their growth compared with uninoculated plants in the same soil. A similar comparison was made between plants grown in a normal compost, and it was seen that the effect of the aucuba mosaic was more severe in the plants grown in the soil under examination. Virus

disease did not appear in the uninoculated plants after four months growth. A large proportion of the plants grown in the soil under examination were attacked by *Phytophthora parasitica* ("damping off"), and examination of the roots of the plants surviving at the end of four months shewed that in almost every case disease was present. A similar series of tests in which some of the soil was sterilised by steaming shewed that aucuba mosaic was less severe in the steamed than unsteamed soil. This effect might have been due to the destruction of substances in the soil which affected the severity of the disease or factors other than the elimination of fungus diseases.

Tomato seedlings grown in water extracts from the soil for three weeks shewed that the effect of any injurious substances was counteracted by that of beneficial substances. No virus disease developed in the plants obtained by potting the seedlings after three weeks growth in the extract.

Many substances were obtained from the soil under examination by extracting with solvents and treating the extracts with other solvents and precipitants. Of the substances many were obtained in such small amounts that it was impossible to retain sufficient material for purification and identification after conducting experiments regarding their effect on the growth of tomato seedlings. Probably many of the substances isolated were mixtures rather than definite chemical compounds. The effects of these substances isolated were determined by growing tomato seedlings in solutions and suspensions of known amounts of the substances in distilled water. Where sufficient material was available seedlings were grown in small amounts of soil containing varying amounts of the isolated substances.

A number of these substances were found to have an injurious effect on seedlings when present in amounts of the order of one part in a thousand parts of distilled water, but in no case did virus disease develop in plants obtained by potting up seedlings after three weeks growth in water culture.

No injurious effect was observed where the substances were added to soil although in some cases they were present in amounts approximately equivalent to twenty times the amount originally present in the soil if their extraction is regarded as complete. In general the injurious substances were present in the soil in extremely small amounts, and it is probable that such are present in all soils where their effect is neutralized by the action of other substances.

10. The Eelworm Disease of Cyclamen.

O. B. ORCHARD.

Unhealthy cyclamen plants have been received from a number of growers in various parts of the country. Examination shewed many of the leaves to be in a shrivelled condition. Finally these wilted and died: growth was much retarded; the plants failed to develop full-sized leaves and flowers, and large numbers could not be marketed.

On one nursery under observation the plants were so hard and dwarfed in the "sixty" pots that it was not possible to continue cultivation beyond this stage.

The amount of damage to the root system varied considerably in the plants examined. Many plants with wilting foliage shewed only a few decayed roots, but the most stunted plants possessed a good deal of dead and brittle root with characteristic swollen portions. From these swellings the cyclamen eelworm, *Heterodera marioni*, was easily isolated.

The first symptoms of damage by this pest may be apparent in severe infestations as early as May and June. When infection occurs at such an early stage the young plants harden and lose a number of roots without producing new ones. If the plants are well developed before infection occurs wilting of the foliage often takes place without any apparent loss of root.

Towards the latter part of the summer the plants partially recover, but as soon as they are taken into the houses further wilting occurs very rapidly.

The cyclamen eelworm may be introduced in a number of ways. Observations on nurseries where this pest has given trouble during the past season suggest, in one case, the introduction of the pest through the use of old stacked cow manure in the compost, and in another case by means of maiden loam.

A number of chemical compounds in solution have been applied to plants or mixed with the compost in an attempt to control the cyclamen eelworm. These include the following:—carbon bisulphide, nicotine, para-di-chlorbenzene, pyridine, aniline, malachite green, methic green, auramine, brilliant green and naphthalene. No substances gave any control of the pest at strengths not detrimental to plant growth. Other workers have also failed previously to discover a chemical means of control.

Control measures.

As the cyclamen eelworm lives and breeds inside the roots of the plant it will be understood that once a plant is infected control becomes practically impossible.

Cyclamen may be very successfully cultivated in soil which has been sterilized by baking or steaming, and growers of this crop are therefore advised to propagate and cultivate in sterilized soil only. Further, if the previous year's crop was infected, the ground should be saturated with a solution of mercuric chloride before using the frames again. The solution should be applied about the middle of April at a strength of 1 ounce in 50 pints water (1 in 1,000).

If these precautions are not taken re-infection may occur through the pots when the plants are transferred to outdoor quarters.

3. Entomological Investigations.

1. A Parasite of the Tomato-moth Caterpillar.

E. R. SPEYER.

The parasite *Comedo opaculus* Thoms., (See Annual Report, 1933, page 72) overwinters in the pupal stage.

Emergence of adult parasites from the pupæ obtained in the autumn of 1933, began in February, 1934, and continued until the middle of May.

The main emergence occurred from February 22nd to March 27th, during which period 212 females and 62 males were obtained, giving a percentage of 77 females and 23 males.

These were kept in a breeding house in which caterpillars were feeding upon tomato plants: later, lettuce was used principally as a food for the caterpillars.

Considerable numbers of parasitised caterpillars were found in this house on April 17th, and emergence of adult parasites of the first spring generation took place on May 8th

Subsequently, considerable numbers of adult parasites were liberated in a small tomato-house in which caterpillars were numerous, but the parasite effected no control of its host.

By the middle of June, the supply of caterpillars became low, this marking the period when the majority have gone to ground and transformed to chrysalids.

The number of parasitised caterpillars obtained in July and August was so small, that the project of breeding this parasite for economic control of the Tomato-moth was abandoned.

The parasite appears to be ill-adapted to its host for the following reasons:—

- (1) The adult parasites are inactive.
- (2) One parasite usually lays all its eggs upon one caterpillar.
- (3) Several parasites often lay all their eggs upon one caterpillar.
- (4) With rare exceptions, the parasite only deposits eggs upon caterpillars of about 1 inch in length, and then only at a time immediately after a caterpillar has moulted.

(5) The parasite is unable to reproduce itself parthenogenetically.

(6) During the summer-period of pupation of the tomato-moth, the parasite appears to require a second host upon which to breed.

2. Predators upon Red-spider Mite.

Twenty adult *Stethorus punctillum* W.S., a small black lady-bird which feeds in its larval and adult stages upon the Red-Spider Mite, were received by air-mail from Mr. R. Schimp, of Hoeylaert, Belgium, on May 12th. The lady-birds started to lay eggs at the beginning of June, during which month considerable numbers of larvæ made their appearance upon Hydrangea plants. Towards the end of the month, it was found that the predator had distributed itself to some rose plants in a greenhouse at a distance of some 150 yards from the breeding house.

During July, efforts were made to induce the lady-bird to feed upon the mite situated on tomato, bean, and carnation plants, but these were unsuccessful, and during the hot summer the predator disappeared entirely.

It is probable that this insect will thrive only in shady places: it is known only to effect some control of the mite in vineries.

No fresh information has been obtained in respect of the Cecidomyid fly *Therodiplosis persicae* Kieff., the red larvæ of which feed especially upon the eggs of the mite, further than that this predator continues to increase annually in the Lea Valley and other districts.

3. Thrips.

Thrips nigropilosus Uzel.

On February 2nd, specimens of this insect (adults of the brachypterous form only) were received from the Kent Educational Committee: they were causing considerable injury to Chrysanthemum cuttings. This insect is known to occur in England, but apparently has not been previously recorded in glasshouses. In Scandinavia and U.S.A., it is sometimes a serious pest of the Chrysanthemum plant. The injury appears as extensive brownish-red markings at the base of the petioles, and the foliage is marked with brownish warty patches.

Nicotine-naphthalene-magnesium hydrate dust (see Annual Report, 1933, page 74) was applied to the foliage, after which no further injury was reported.

Scirtothrips longipennis **Bagnall.**

Cyclamen flowers upon a nursery in Surrey were severely injured in October by this insect, which occurs as a pest of various hot-house plants in Europe and U.S.A. Insects in all stages of development were present in the flowers received on October 12th. On November 1st, after treatment with naphthalene-nicotine-magnesium hydrate dust (Annual Report, 1933, page 74), flowers contained only comparatively few adult insects. It is suspected that the cyclamen flowers became infected from other plants growing upon the nursery.

Onion Thrips.

Outbreaks of *Thrips tabaci* Lind. upon cucumber and melon plants have again successfully been brought under control by application of naphthalene-nicotine-magnesium hydrate dust.

Rose Thrips.

This dust has NOT proved successful in the control of *Thrips fuscipennis*, Hal, but applications of Pyrethrum dust appear to give good control of this pest. Whereas the former dust kills insects WITH WHICH IT ACTUALLY COMES INTO CONTACT in a period of two or three minutes, the action of the latter is much slower, but has a more lasting effect, so that a considerable protection is afforded to the young growth and flower-buds in which the insect lays its eggs. Upon nurseries where this insect makes its appearance already in spring, dusting with Pyrethrum should not be started later than the beginning of March.

4. The Greenhouse Symphilitid.

Stunted tomato pot-plants were brought to the Experimental Station from a neighbouring nursery on February 16th. In addition to a "blue" appearance of foliage and stem, marks of gnawing round the "collars" of the plants were apparent.

The soil of the pots, which were standing upon the ground prior to planting out, contained numbers of the Greenhouse Symphilitid (*Scutigerella immaculata* Newpt.), a centipede-like animal known as "white insect" in the Channel Islands.

Groups of plants in 6 inch pots were watered with 5 fluid ounces to each pot, of mercuric chloride solutions at varying dilutions, with the following results:—

HgCl ₂ Dilution.	% Symphilids killed.				Days after treatment.		
1 = 3,000	...	...	100	...	...	...	4
1 = 4,000	...	...	100	...	...	...	5
1 = 5,000	...	...	60	...	...	...	5
1 = 7,500	...	...	40	...	...	...	5
1 = 10,000	...	...	30	...	...	...	5

The animals were also killed or vacated the soil, when excessive watering was resorted to.

The pot-soil of unaffected plants upon the nursery was found often to contain as many of these animals as that of plants which shewed the "blueing" symptoms.

It was therefore suspected that the symphilids might not be the cause of the injury.

Examination of contents of the intestine of several specimens shewed the presence of numerous bacteria, and doubtfully of broken-down plant tissue, thus suggesting that the animals might have been feeding upon decayed vegetable matter.

From one plant shewing symptoms, the fungus *Thielavia basicola* Zoph. was isolated.

Fresh plants potted in fresh soil into which many symphilids were introduced grew normally and exhibited no symptoms.

Fresh plants potted in the original soil free from or containing symphilids only, exhibited no symptoms.

Fresh plants planted in a box containing the original soil in which symphilids and young woodlice were present, without exception shewed severe symptoms on the 6th day after planting, but the fungus *Thielavia* did not make its appearance in the plant tissues.

Fresh plants potted in soil containing woodlice only, shewed symptoms, with gnawing of the "collar," in only one case, but many woodlice escaped from the pots. Symptoms were produced by mechanical injury to the roots, but complete ringing of the "collar" did not do so.

It only came to light at a later date that the soil surface upon which the plants stood on the nursery was teeming with the woodlouse *Armadillium vulgare* Latr. Efforts to produce symptoms with *A. speyeri* Jackson later failed, though gnawing of the "collars" occurred.

It still remains to be proved definitely whether the injury is attributable to the woodlouse, *A. vulgare* Latr. or whether under certain conditions the symphidid may yet be the cause.

5. A pest of Lettuce.

A small white spring-tail *Onychiurus armatus* Tulb, caused injury to the foliage of lettuce growing under glass at Cheshunt, in November, 1933, and was again observed in February, 1934.

Any leaves touching the soil, and in severe cases those of the younger foliage, are at first pitted and then partially skeletonised. The insects feed at night. Control was easily obtained by sprinkling small amounts of flake naphthalene upon the soil surface in the vicinity of the plants.

6. Spraying in control of the Tomato-moth Caterpillar.

The relative merits of lead arsenate, cryolite and cuprous cyanide, the latter kindly supplied by Messrs. Imperial Chemical Industries, Ltd., were tested as poison sprays for the control of tomato-moth caterpillar. At the time of these trials, an assurance was given to the effect that cuprous cyanide was a stable compound, and from the results of experiments upon rats, was in all probability non-poisonous to man.

It has since been established that this compound is not stable, at least under certain conditions, and under these circumstances, it would become extremely dangerous. Its use for spraying purposes can therefore, for the present, not be recommended to growers.

Owing to the natural mortality amongst very young caterpillars, and their susceptibility to poisons which do not act upon older caterpillars, only those ranging from $\frac{3}{4}$ inch to $1\frac{1}{4}$ inch were used in the following experiments.

Within a limited space, only few individuals can be subjected to experiment, as overcrowding is liable to taint the results obtained.

The three substances mentioned are distasteful to and recognisable by the caterpillars. If not hungry when first encountering sprayed foliage, a caterpillar may eat a small portion of a leaf, upon which there is not sufficient residue to cause death: this caterpillar will then refuse to feed upon sprayed foliage, and in absence of untainted food, will die of starvation, a process which may last for a period of as long as ten days.

Though in experimental work the ultimate results may be the same, in practice, caterpillars are usually able to obtain untainted food from unsprayed portions of the stem and fruit, or from weeds which may occur in the glasshouse.

Series 1.

Whole plants in pots sprayed, caterpillars introduced after the spray had dried upon the foliage, and the plants surrounded with muslin.

(a) LEAD ARSENATE PASTE, 6 lbs. to 100 gallons water + saponin.

Four caterpillars. On fourth day after spraying, three dead, one moribund.

(b) CRYOLITE, 6 lbs. to 100 gallons water (see Formula, Annual Report, 1933, page 71).

Five caterpillars. On fourth day after spraying, two dead, two moribund, one not feeding.

(c) CUPROUS CYANIDE (coarse grade), 6 lbs. to 100 gallons water + saponin.

Four caterpillars. On fourth day after spraying, one moribund, two not feeding, one unaffected.

(d) CUPROUS CYANIDE (coarse grade), 3 lbs. to 100 gallons water + saponin.

Nine caterpillars. On seventh day after spraying, five dead, three moribund, one not feeding.

(e) CUPROUS CYANIDE (coarse grade), $1\frac{1}{2}$ lbs. to 100 gallons water + saponin.

Six caterpillars. On seventh day after spraying, three dead, one moribund, two not feeding.

Series II.

Foliage from the plants of Series I. was fed daily to caterpillars kept in large jars.

- (a) Four caterpillars. On eighth day, three dead, one moribund.
- (b) Three caterpillars. On sixth day three dead.
- (c) Three caterpillars. On eighth day, two dead, one moribund.
- (d) Four caterpillars. On eighth day, four dead.
- (e) Three caterpillars. On eighth day, two dead, one not feeding.

The amount of foliage eaten in both series, was most in (b) cryolite, less in (a) lead arsenate, (d) and (e) cuprous cyanide, and least in (c) cuprous cyanide. The results of the two series appear to shew that cryolite acted as an efficient poison, and rendered foliage least distasteful to the caterpillars: that too heavy a deposit of cuprous cyanide upon the foliage deters them from feeding at all, and that the action of the latter compound, when used at 3 lbs. to 100 gallons water is very similar to that of lead arsenate.

Messrs. Imperial Chemical Industries, Ltd., kindly supplied a sample of cuprous cyanide in a much finer state of division than that used in the previous experiments. This was applied as a spray, at the rate of 3 lbs. to 100 gallons water, to which 2 ounces saponin had been added, to thirty-eight well-grown tomato plants in pots.

After spraying, four plants were taken at random and removed to a special large cage; eight caterpillars of suitable size were placed upon them. During the ensuing seven days, six caterpillars died, and the other two were in a moribund condition.

To the main set of plants, thirty-seven suitable caterpillars were introduced. On the eighth day after spraying, a thorough search led to the finding of only nine caterpillars in the glass-house, of which three were dead, two moribund, one shewed slight signs of poisoning, and only two appeared to be unaffected. One plant only had been damaged to a noticeable extent. No scorching of the foliage or retardation of growth took place subsequent to spraying.

7. Poison-baits for Woodlice.

Extensive experiments were carried out to determine if cuprous cyanide could be substituted for Paris green in the bran or dried-blood mixture in use as poison-baits for woodlice.

In experiments in which the baits were freshly made up and kept quite dry, cuprous cyanide acted as an efficient poison, but decomposition of the compound, with consequent complete loss of efficiency, resulted when they were used upon a commercial scale.

8. Chrysanthemum Pests.

During August several complaints of injury to very young chrysanthemum plants standing out-of-doors were received. The injury in more than one case was attributed to earwigs. An investigation upon a local nursery revealed that the cause of the damage was due, not to earwigs, but principally to leaf-hoppers, and to a lesser extent to capsid bugs and aphids. These insects had invaded the plants from the numerous weeds in the vicinity. Upon the nursery in question, the plants were sprayed with a good proprietary nicotine wash at intervals of four days, and after a few applications, no further trouble was experienced.

9. "Cyanide" Fumigation.

A glasshouse of 3,000 ft. cubic capacity containing well-grown soft tomato plants, variety Kondine, ripening the first and second trusses, was fumigated with hydrocyanic acid gas according to the recommendation made by W. E. Collinge in 1912.

By this method, a comparatively large volume of the gas is generated, but the duration of the fumigation is only for a period of from twenty to thirty minutes.

The fumigation was carried out at dusk, with the temperature of the glasshouse at 52°F. Two large glass jars each containing ten fluid ounces of 33% solution of sulphuric acid were placed upon the path, and into each 2½ ounces powdered sodium cyanide were dropped. The total amount of sodium cyanide employed, *viz*, 4½ ounces is equivalent to 1½ ounces per 1,000 cubic feet space, *i.e.*, rather more than six times the amount used in all-night fumigation for white fly.

The ventilators and doors were opened twenty minutes after the gas had been generated. Not enough insects were available at the time to judge of the effect upon them, but the

plants were entirely uninjured : most of them had been allowed to get fairly dry at the root before the fumigation, but water was given to several immediately before, and the latter also shewed no signs of scorching. The plants were kept under observation for a period of three weeks after the treatment.

It is known that this method is effective in the control of such insects as mealy-bug, and doubtless insects which are difficult to kill by the long period and weak concentration method, would more easily succumb to the larger concentration used over a short period.

The difficulty at present lies in the danger of generating a comparatively large volume of gas, and until means are found of mechanically dropping the cyanide into the acid from outside the house, the method cannot be practiced upon commercial nurseries, or in greenhouses with a cubic capacity of more than 1,000 cubic feet.

4. Insecticide & Fungicide Investigations.

1. General.

W. READ.

Further attempts have been made to find a substitute for petroleum oil emulsions which are used for controlling the red spider mite, and also a fungicide for controlling tomato leaf mould which will leave no visible deposit on the fruit. Many emulsified synthetic solvents were tested as insecticides but in no case was a satisfactory control of red spider obtained without damaging the plants.

Mention is made elsewhere in this Report of the use of oil-soluble copper compounds in the control of rust on roses. A spray containing an emulsified solution of copper oleate in cottonseed oil did not control rose rust so effectively as was anticipated after last year's experiments.

Many different proportions of copper oleate, cottonseed oil and an emulsifying agent were tried and the best results were obtained by emulsifying equal volumes of a 20% glue solution and a 50% solution of copper oleate in cottonseed oil. The copper oleate solution was a fairly stiff grease at normal temperatures and the emulsification process was conducted at approximately 60°C. The product was a stable emulsion, sufficiently fluid to mix easily and creamed very slowly when diluted to one in hundred and twenty with hard water. At this strength good spreading was obtained on rose foliage and rose mildew (*Sphaerotheca pannosa*) was effectively controlled.

Emulsified solutions of copper oleate in a white petroleum oil such as is employed in the petroleum emulsions used for red-spider control were not so satisfactory. Emulsification of these solutions was more difficult and injury followed their application to roses. Evidence has been obtained that petroleum oils enter the leaf tissue to a greater extent than does cottonseed oil, and the injury caused by petroleum solutions of copper oleate is attributed to the entry of the copper soap in solution into the leaf tissue.

The emulsion of 50% copper oleate cottonseed oil solution was not effective in destroying the red-spider mite.

Other oil soluble compounds are being investigated, one of which gives little increase of viscosity when dissolved in petroleum and vegetable oils. Unfortunately emulsified petroleum solutions of this substance cause injury to plants when applied at concentrations sufficient to kill red-spider and tomato leaf mould. This is also due to the penetration of the leaf surface by the petroleum solution. When plants were sprayed with a suspension of this substance no injury was

caused although the amount of copper retained by a unit area of leaf surface was more than twice that retained from an emulsified petroleum solution which caused serious damage. The diluted suspension applied contained a greater amount of the emulsifying agent than did the diluted petroleum-solution emulsion and the petroleum used was without injurious action. Injury also followed the application of a petroleum emulsion to the plants previously sprayed with the suspension.

Further experiments are being made with emulsified solutions of this compound in vegetable oils and synthetic solvents.

A number of substances have been tested as fungicides for use against soil fungi, particularly *Phytophthora parasitica*, the organism responsible for "damping off" of tomato seedlings.

The dyes malachite green, brilliant green, methic green and auramine did not give a complete control of the fungus when the soil was soaked with one in four hundred solutions whilst the germination of tomato seed and subsequent growth of the seedlings was delayed.

2. The Effect of Sulphur Vaporization on Tomato Leaf Mould.

O. ORCHARD.

The experiments in controlling tomato leaf mould by the vaporization of sulphur described in the Nineteenth Annual Report, page 67 have been continued.

This season, the experiments were arranged to test the possibility of preventing attacks of this disease by vaporizing sulphur before it appeared.

The experiments were conducted in three chambers, each containing sixty tomato plants, planted and grown under standard commercial conditions.

Three similar chambers were used as controls.

The first vaporization was conducted on June 5th, before mildew was observed, and was then repeated at intervals of fourteen days. Sufficient sulphur was applied to leave a faint yellow deposit on the foliage. Mildew appeared about ten days after the first vaporization, and continued to spread rapidly throughout the plants.

By the first week in August the plants were so severely infected by mildew that the experiment was discontinued, and other control measures were adopted. It would, therefore, appear that although a very efficient vaporizing apparatus has been employed, vaporization of sulphur cannot be recommended as a preventative or a control of tomato leaf mould under commercial conditions and the present system of ventilation of houses.

5. Chemical Investigations.

O. OWEN.

1. General.

The number of samples of soil, water, etc., submitted for examination continues to increase. Of importance in the work on soils has been the fact that several cases of injury to plants have been traced to the presence of chlorate in the soils. On one nursery a chlorate weed killer had been applied on the paths, etc., round the houses. Fairly heavy rain fell when the tomato plants in the houses were about four feet high. Within a few days the plants were shewing a typical chlorate mottle. On examination the soil in which they were growing was found to contain 0.006% of chlorate as sodium chlorate. On another nursery several successive batches of young tomato plants shewed symptoms of chlorate poisoning. The soil was found to contain about 0.005% sodium chlorate. In this case a chlorate weed killer had been used on the nursery, and it appears that the watering cans which had been used for it had not been cleaned out thoroughly.

As sodium chlorate is easily soluble in water and non-poisonous to animals but exceedingly toxic to plants it is almost an ideal weed killer. At the same time care must be exercised in its use. There appears to be a good deal of variation in the susceptibility of various plants to its action. It is quite certain that tomato plants are particularly susceptible to it. At the Station we have found it a task of some difficulty to wash out the chlorate from the pots themselves when they have contained soil to which chlorates have been added. So it cannot be emphasised too strongly that care in its use is essential.

The continued drought has accentuated the salt problem. In those districts where salt is a common constituent of the surface water used on nurseries the water supplies have been a continual source of anxiety. One grower whose usual supply had dried up sent samples from alternative sources. They varied in salt content from 0.221% to 0.557% of sodium chloride. As this grower's soil already contained more salt than is usually considered desirable none of the samples could be recommended. These are exceptionally high figures but they illustrate the difficulties which may be experienced in districts known to be salty. At the same time it may be mentioned that satisfactory crops are grown in one area where the supply sometimes contains 0.1% of sodium chloride. Again

we would advise growers to bear this point in mind when contemplating the erection of new glass. If there is any doubt an analyst should always be consulted.

A number of fertilisers have been submitted for examination and as in previous years we have been unable to find them responsible for the injurious effects attributed to them. Several waste products suspected to have manurial value have also been examined. In more than one case it has been found that the unit value has been so low as to be insufficient to cover the cost of transport.

2. The Potash Content of the Pulp of "Blotchy" Tomato Fruits.

Since there is such a definite relation between the incidence of "blotchiness" in tomato fruit and the amount of potash applied to the soil a determination of the potash content of such fruit was made, with the results shewn in Table 1. "Blotchy" fruits were taken at random and the yellow and red parts of the pulp cut out as carefully as possible. The samples were dried and analysed for potash in the usual way,

TABLE 1.

					"Yellow" pulp.		"Red" pulp.
Water	...	...	...	per cent.	96.83	...	96.99
Dry matter	...	...	...	" "	3.17	...	3.01
Ash in dry matter	...	...	...	" "	9.855	...	9.598
Potash (K_2O) in ash	...	...	...	" "	45.98	...	52.43
" " " dry matter	...	...	...	" "	4.531	...	5.032
" " " pulp	...	...	...	" "	.1434	...	.1516
Relative K_2O in fresh pulp	...	...	...	" "	100	...	105.7

The red pulp contains more potash than does the yellow pulp, but the difference is not large and it is hoped to repeat the analysis on a number of samples next season.

3. The Effect of Manurial Treatment on the Mineral Constituents of Chrysanthemums.

The analysis of chrysanthemum plants grown in old tomato soils used for a number of years for manurial experiments has been continued. The amount of some of the mineral constituents in the ash are given in Table 2. These are referred to the dried material basis in Table 3, which includes also the absolute amounts per plant.

Table 2.

Treatment.	Percentage in Ash.					
	Silica SiO_2	Iron + Alumina $\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$	Lime CaO .	Magnesia MgO .	Potash K_2O .	Phosphoric Acid P_2O_5
Unmanured	3.381	2.741	23.79	6.033	36.13	5.376
Complete Artificials plus Dung	2.549	3.345	17.40	5.140	38.89	7.295
Complete Artificials	3.722	3.242	18.61	5.129	37.95	7.068
Phosphates omitted	2.026	2.042	19.21	3.741	40.69	6.362
Nitrogen omitted	5.088	4.044	13.41	3.042	37.18	9.126
Potash omitted	3.445	3.523	16.78	3.816	41.78	6.067

Table 3.

	Percentage in Dried Material.							Dry Weight Per Plant.	Contents per plant grams (average of 12).						
	Ash.	Fe ₂ O ₃ ⁺ Al ₂ O ₃	CaO.	MgO.	K ₂ O.	P ₂ O ₅	SiO ₂		Ash.	Fe ₂ O ₃ ⁺ Al ₂ O ₃	CaO.	MgO.	K ₂ O.	P ₂ O ₅	SiO ₂
Unmanured.	7.30	.5940	1.737	.4403	2.637	.3940	.2468	12.08	.8816	.07174	.2097	.05319	.3185	.04746	.02981
Complete Artificials plus Dung.	9.968	1.061	1.734	.5124	3.893	.7276	.2540	18.91	1.885	.2005	.3278	.09690	.7360	.1376	.04803
Complete Artificials	9.939	1.025	1.849	.5097	3.775	.7030	.3698	15.00	1.490	.1552	.2773	.07645	.5662	.1054	.05547
Phosphates omitted	8.342	.7011	1.603	.3121	3.394	.5308	.1690	13.83	1.154	.09699	.2217	.04317	.4695	.07341	.02337
Nitrogen omitted.	9.675	1.275	1.297	.2943	3.596	.8828	.4922	11.75	1.086	.1498	.1524	.03457	.4228	.1038	.05785
Potash omitted.	9.871	.9464	1.657	.3766	4.123	.5988	.3401	9.30	.9179	.08802	.1541	.03507	.3836	.05569	.03163

Reference to Table 3 shews that, if the complete artificial figures be taken as a basis, absence of manure depresses all the amounts whether they refer to percentage composition or the actual amounts in the plant.

On the same basis treatment with complete artificials plus dung increases all the amounts except percentage lime, and silica which is depressed in percentage and actual amount.

The effect of the omission of phosphates is of interest. It will be remembered that in the case of tomato foliage, the omission of phosphates caused a striking reduction in the percentage of potash in the dried foliage. Here the reduction is small. All the other percentages are depressed and in the amounts the differences are greater. Omission of nitrogen depresses the percentages of ash, lime, magnesia and potash, but increases those of iron plus alumina, phosphoric acid and silica. The total amounts are depressed for all constituents except silica.

The omission of potash.

In the case of tomatoes the omission of potash from the fertilizer was accompanied by a definite increase in the percentage of phosphoric acid in the dried foliage. In the case of chrysanthemums such is not the case. In fact all the percentages are reduced except the potash itself, which curiously enough, shews an increase. In the case of the quantities per plant, however, all constituents are reduced considerably by the omission of potash.

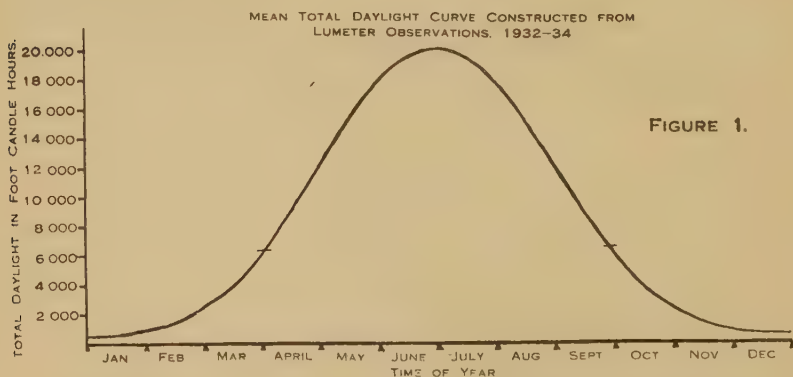
6. Physiological Investigations.

1. The Effect of Light on Growth and Differentiation in Tomato Seedlings, Variety E.S. 1.

B. D. BOLAS AND I. W. SELMAN.

Previous work, published in this Report, has shewn the relationship between light, temperature and assimilation rate for seedling tomato plants, variety E.S.1., the assimilation being measured during a single day. It must be recognised, however, that although these determinations in all probability serve as an approximate indication of the optimum combination of the two factors, light and temperature, some care is necessary in applying to crop plants the conclusions drawn from them.

It may well be that owing to secondary effects such as the accumulation of assimilate in the leaves and possibly other changes, an optimum combination of factors as determined by an experiment lasting a few hours may prove to be somewhat removed from the optimum in relation to assimilation over a longer period.



With a view to investigating this, experiments were carried out during 1934, in which the dry weight of seedlings was determined at intervals throughout the year, and at the same time an approximate estimate was made by frequent lumeter readings of the total amount of light available during a normal day at different times of the year. This is shewn as a smoothed curve, Figure 1. The length of day *i.e.*, number of hours between sunrise and sunset was also calculated. Figure 2.

From earlier work (Cheshunt Annual Report, 1933) it will be seen that under the conditions normally obtained in the greenhouses there is no evidence of any increase in assimilation rate during a single day with increases of light above a total of 6,500 foot candle hours, which is reached at the beginning of April, the mean total light does not fall below this until the end of September. Thus if the forecast made from assimilation measured over a single day is correct, one would expect to find no significant difference in assimilation rate between say mid April and mid August, and in fact as shewn by reference to Figure 3 the growth rates for these months are almost the same and produce strong confirmation of the earlier work.

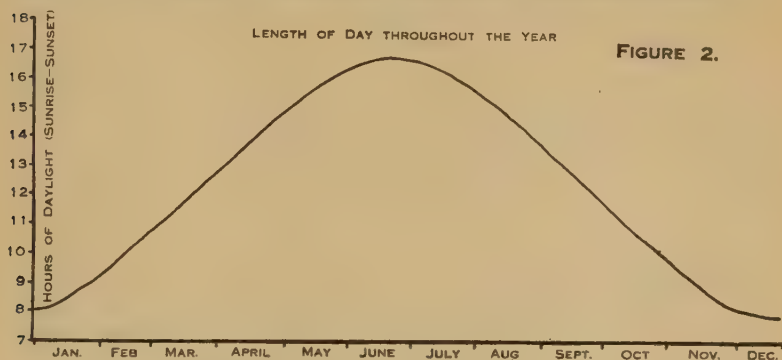


FIGURE 2.

If instead of the seasonal changes in rate of increase in dry weight, the dry weight of the plant at a particular stage of development of the plant is taken, a very different relationship is found. These may be tabulated as follows:—

Month.	Weight of plant in gms. at seventh leaf stage.				
January ...	...	...	...	...	·1
February ...	...	...	...	...	—
March ...	...	...	...	...	—
April ...	...	...	...	...	·5
May ...	...	...	...	...	·7
June ...	...	...	...	...	·8
July ...	...	...	...	...	—
August ...	...	...	...	...	·8
September ...	...	...	...	...	—
October ...	...	...	...	...	—
November...	...	...	...	...	·2
December ...	...	...	...	...	·2

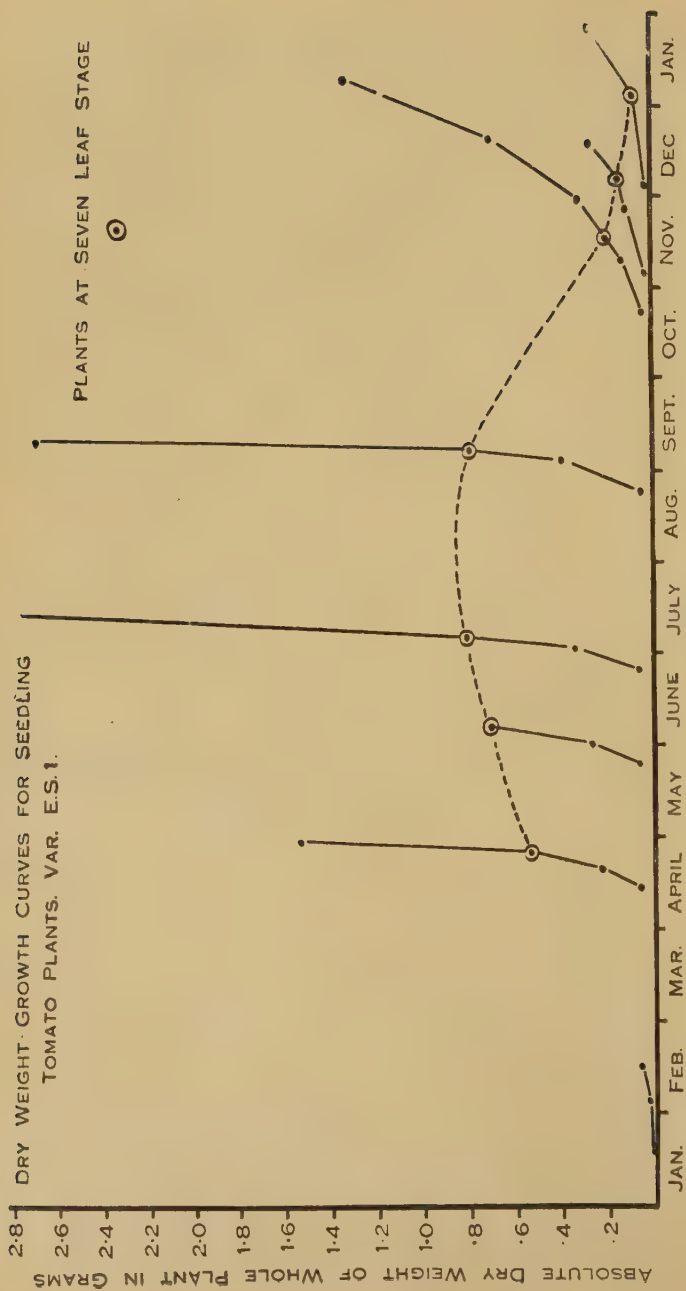


Figure 3.

These results are shown on the dotted curve in Figure 3, the circles corresponding to the plant weight at the time of unfolding of the seventh leaf.

It will be seen that this curve bears a close resemblance to both the curve for total illumination and the curve for day length, but that the maximum is moved to the right, suggesting that whichever of these factors is responsible for the control or partial control of leaf growth takes some weeks for its effect to show during the summer months.

Further work is required in order to elucidate the relationship, but there is strong evidence that although illumination may be such that it no longer limits assimilation, yet the effect of increasing total illumination or day length has very important effects on the differentiation or development of the plant.

2. Some Aspects of the Water Relations of Tomato Plants.

I. W. SELMAN.

In the study of the water requirements of plant tissues or organs several criteria have been recognised. Two of these are considered below.

(1) The *suction pressure* of the cells. This may be regarded as the force with which water tends to be drawn into the cells. It is regarded as the resultant of two opposing forces, the osmotic pressure of the cell sap, tending to draw water into the cell, and the elastic recoil of the distended cell wall tending to force water out of the cell.

(2) The *water deficit* of the cells. In this work the water deficit is defined as the number of grams of water that 100 grams of tissue must take up in order to reduce the suction pressure of the cells to zero.

The object of this work was primarily to investigate the water relations of the leaf. Certain practical difficulties were experienced in obtaining measures of these, but a reasonably satisfactory technique has now been evolved.

Technique.

Suction pressure was determined by finding a cane sugar solution whose osmotic pressure, tending to withdraw water from the leaf, exactly balanced the suction pressure tending to pull water in. In practice, similar leaves were immersed for 90 minutes in three sugar solutions and the percentage changes

in fresh leaf weight were determined. Since there is practically a linear relation between change in fresh weight and concentration of external sugar solution over the range 0.0 to 0.6 molar cane sugar, it was easy to determine graphically the osmotic pressure of the sugar solution in which the leaf undergoes no change in fresh weight.

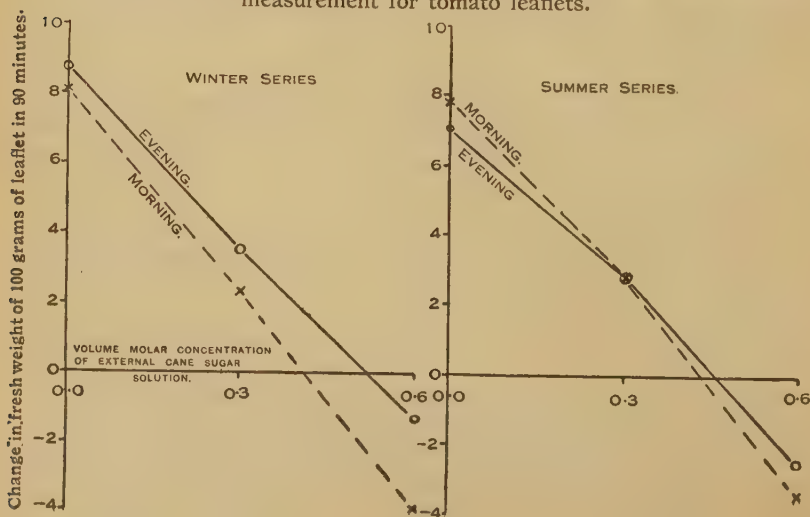
Water deficit was determined by estimating the amount of water taken up on complete immersion of the leaf in distilled water. With young tomato leaflets (plants at eight leaf stage) measurements were made at 90 minutes, and with tobacco leaves (plants at fifteen leaf stage) at $3\frac{1}{2}$ hours. A more critical description of the technique will be published elsewhere.

Seasonal and Diurnal Changes in Suction Pressure and Water Deficit.

In these experiments sixty similar leaflets were removed from twenty plants at 9.0 a.m. and divided into three groups which were immersed in water, 0.3 m. and 0.6 m. cane sugar solutions respectively, for 90 minutes. The percentage change in fresh weight of each leaflet was determined, and at 4.0 p.m. the experiment was repeated on the leaves from twenty plants previously "paired" with the morning sample (Bolas and Melville *Ann. Bot.*, 1932). The results of nine summer experiments and five winter experiments are shown graphically in Figure 1.

Figure 1.

Seasonal and diurnal changes in suction pressure and water deficit measurement for tomato leaflets.

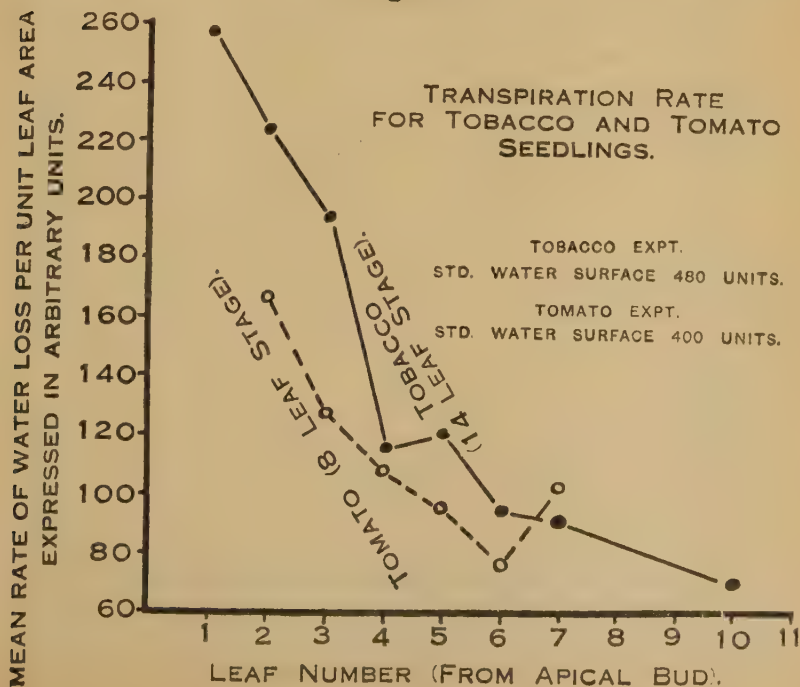


It will be seen that the suction pressure (or equivalent osmotic pressure of the external cane sugar solution) rises markedly during the day in the summer, whereas no significant change occurs in the winter. That this rise is due to an increase in the osmotic pressure of the cell contents, and not to any large change in the elasticity or extensibility of the cell walls, is suggested by the fact that the maximum difference between the morning and evening curves in the summer series is in 0.60 m. sugar where the tension on the cell wall might reasonably be expected to be tending to zero.

Loss of Water by Transpiration.

One of the factors affecting water deficit will be the amount of water lost from the leaf by evaporation to the atmosphere. To ascertain the relative transpiration rates of different leaves on the plant the cobalt chloride paper method was used. Figure 2 shews the relative transpiration rates (expressed in arbitrary units) for the leaves of a tobacco and a tomato seedling. Thus it would appear that in the day the maximum water loss per unit area of leaf surface is from the embryonic leaves, and that the fully expanded leaves lose the least.

Figure 2.



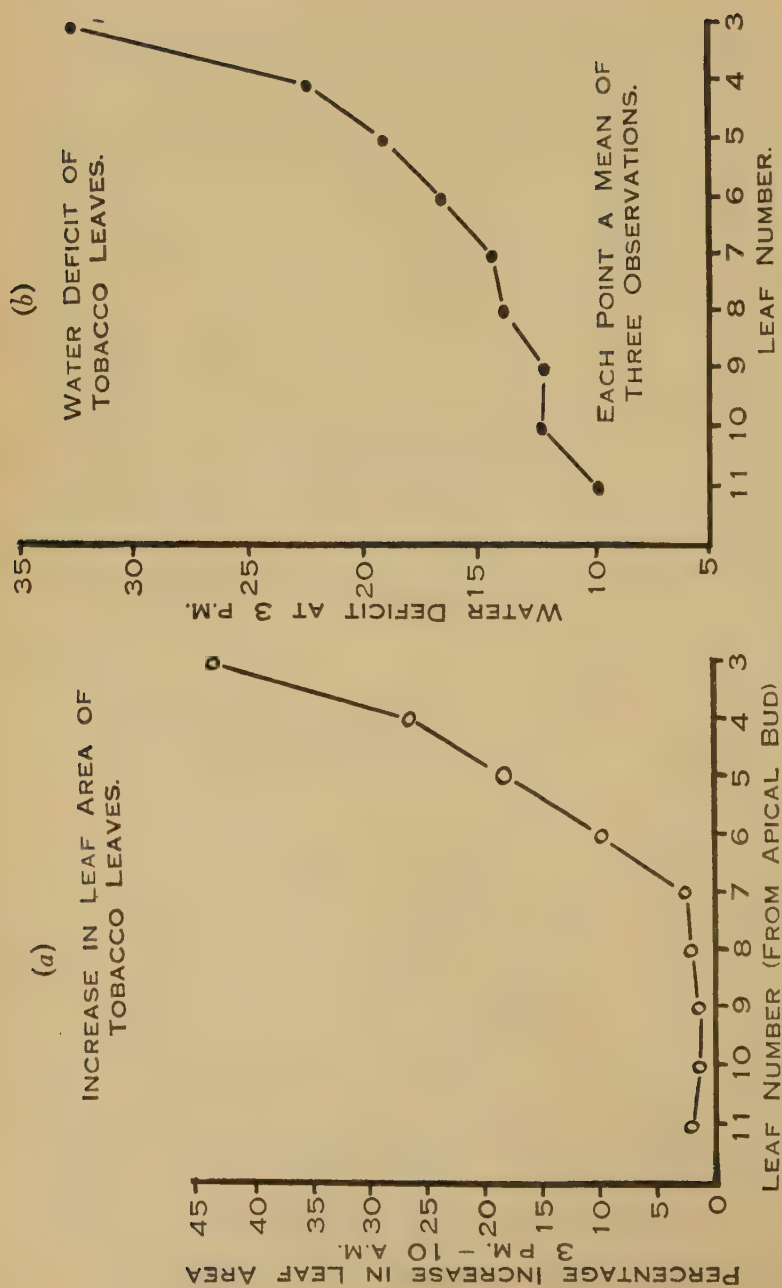


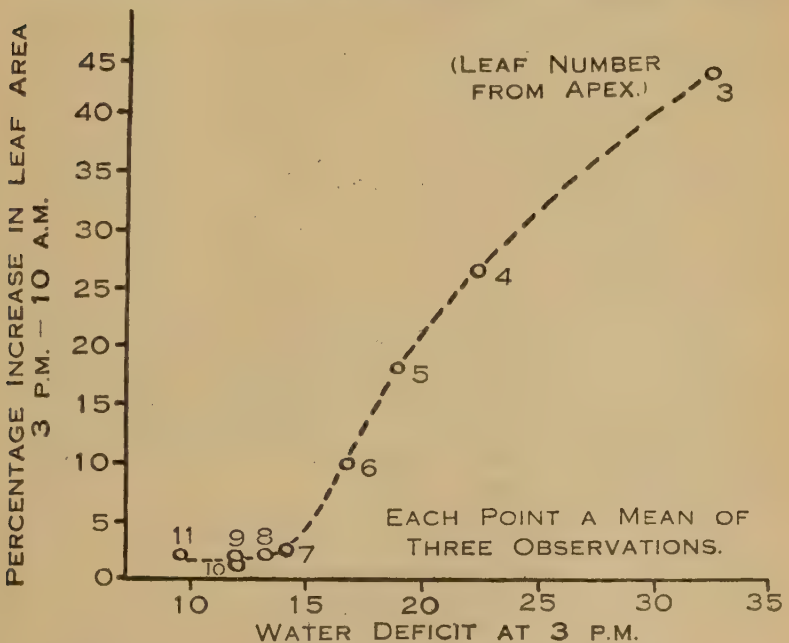
Figure 3.

In Figure 3*b* the water deficits of leaves 3—11 on a fourteen leaf tobacco plant are shewn graphically. From Figures 2 and 3*b* it would appear that high water deficit is associated with high transpiration rate. Since the evaporating power of the atmosphere will be essentially the same for old and young leaves alike, one may suggest that the permeability of the cells of the young leaf in relation to water loss may be higher than the permeability of older leaves.

Growth and expansion of young leaf cells must be dependent in some measure on the degree of turgidity—which may be measured by a determination of water deficit—and it is at night, when transpiration losses are small and the water deficit is made up, that leaf expansion mainly takes place. A high correlation between water deficit and leaf expansion has in fact been found.

Figure 4.

Correlation diagram between increase in leaf area and water deficit for tobacco leaves.



Correlation between Water Deficit and Leaf Expansion.

Two similar tobacco plants were selected and the water deficit of all leaves on one plant was determined in the afternoon. During the following night the increase in area of the

leaves on the second plant was measured. The results are shewn graphically in Figure 3. The high correlation between water deficit and percentage increase in leaf area (Figure 4) appears to afford an indication of the part played by water in distending the cell membranes and enabling growth and permanent leaf expansion to take place.

Significance of Water Deficit and Suction Pressure.

The movement of water in the plant may be regarded as being partially controlled by the suction pressure of the cells. The resistance of the water channels (xylem elements) probably plays some part in controlling water movement in certain plants. The living plant must be regarded as being in a state of dynamic equilibrium in relation to water movement. If transpiration and assimilation cease, then water will tend to move from cells with a low suction pressure to cells with a higher suction pressure, until a static equilibrium is reached. This latter condition apparently does not normally occur in tomato or tobacco seedlings.

Leaf water deficit must clearly be controlled by several factors.

(1) The extensibility of the leaf tissue ;

(2) The amount of water lost in transpiration, which may possibly be a function of the permeability of the tissues in relation to water loss ;

(3) The amount of water fixed in the assimilation of carbohydrates.

The first two factors—extensibility of leaf and transpiration loss—are almost certainly of importance in the question of conditions governing the swelling of fruits, so that although the above results have no immediate practical application it is conceivable that a modified technique along the lines adopted for the study of leaf tissue might yield useful results if applied to questions of fruiting.

3. Vernalization.

H. L. WHITE.

Acceleration of reproduction in certain plants by treatments termed "vernalization" is now a well-known phenomenon. The temperature conditions at the time of germination have been found in many plants to exert a profound effect upon subsequent behaviour and in particular the advent of maturity.

By treatments applied to the seed at the time of germination, especially low temperatures, varieties of cereals that normally mature late have been induced to mature sufficiently early to be harvested in regions, where the earliness of winter would otherwise have caused their exclusion as a commercial crop.

It was not known if such treatments would affect the growth of lettuce, and a preliminary experiment was arranged to test this possibility. Eight varieties—Gotte à Forcer, Golden Ball, Trocadero, Feltham King, Arctic King, Imperial, Hative de Milly, and Golden Globe—were germinated at three temperatures, 2°C., 12°C. and 22°C. Pairs of boxes were planted of each variety and after five weeks the boxes in sets of six were interchanged at random. Plants germinated at low temperatures were the same size, but were readily distinguished by reason of their deeper colour and presumably higher chlorophyll content. With the exception of one box of Milly all the boxes of plants germinated at 22°C. were readily sorted from the boxes of plants germinated at the lower temperatures by a student unable to see the labels. The plants could not be grown to maturity but the experiment demonstrates the potentialities of treatment applied to the seed at the time of germination and opens up a promising line of work.

7. Miscellaneous Investigations.

The Operation of Hand-Fired Boilers for Glasshouse Heating.

L. J. FOWLER, B.A., A.M.I.C.E., AND W. F. BEWLEY, D.Sc.

During the last year an investigation of the methods of operating hand-fired boilers in nurseries has indicated clearly that the average nurseryman, fearing the serious financial losses which are likely to occur through inadequate heating, adopts fuels and methods of stoking which, whilst giving security, only do so at an unnecessarily high cost. In almost every case, with improved methods of firing and regulation of the existing boilers, big economies could be made without risk of damage to crops because of low temperatures.

Chief causes of fuel wastage.

The lowest temperatures usually occur between 4 and 7 o'clock in the morning, and except on large nurseries where a night stoker is employed between these hours, the boilers are nearing the end of their banking period. In buildings, owing to the storage of heat in the building fabric, a reduction in the heat output from the boiler during this time rarely results in an appreciable fall in temperature; but in glass-houses the heat storage effect is practically non-existent, and it is, therefore, essential that the boiler shall maintain at least a constant heat output throughout the night. On banking the fires it is thus necessary to introduce sufficient fuel into the fire box, and adjust the dampers to maintain a regular heat output until the fires are attended in the morning.

Anthracite coal weighs approximately 40 lbs. per cu. ft. and has a calorific value in the neighbourhood of 13,500 British thermal units per lb. The corresponding figures for coke are 25—28 lbs. per cu. ft. and 12,500 British thermal units per lb. When, therefore, a boiler is charged with anthracite the potential heat storage in the fire box is one-and-a-half times that when it is charged with coke.

The grower who rarely has standards from which he can decide whether his heating costs are high or low, seldom complains to his stokers as long as the temperatures in the glasshouses are maintained at the degree demanded by the crops. The stoker has a larger safety margin with anthracite, owing to the increased heat storage capacity of a boiler fire box when consuming this fuel, and not being generally concerned with cost will use it whenever possible,

Inefficient burning of anthracite.

In many of the plants inspected the fires were piled up irregularly with lumps of anthracite and left for as long as twenty-four hours without attention. The ashpit door of the boiler had been removed, or had never been fixed, and the draught was ample. As the fire burnt it became thin in places and eventually the fire bars were exposed. Thus, in many boilers for twenty hours of the day, air streamed through the grate and up the chimneys without restriction, had a cooling effect on the boiler, and reduced its efficiency to the neighbourhood of 30%.

Demonstration of inefficient firing.

To demonstrate the inefficient method of operation employed, tests were carried out in three nurseries which were burning anthracite. During each test the boilers were stoked for twenty-four hours in the normal way by the nursery staff, the fuel was weighed and glasshouse and external temperatures recorded hourly. A second twenty-four hour test was then carried out with gas coke, and in each case the boilers were left banked throughout the night for the period normally observed with anthracite. In the three tests the temperatures were maintained during the night, and at the commercial prices available at each nursery, the savings in the fuel cost varied from 45% to 64%.

In Tests 1 and 3 the external temperatures were in the neighbourhood of 40° F.; but in Test No. 2 the mean external temperature during the coke test was as low as 31·8° F. during the period from 6 p.m. to 7 a.m. During this test the boilers were not touched between 9 p.m. and 7 a.m., and the results demonstrate that, provided the fire box of the boiler is of sufficient capacity and the fire is properly regulated, glasshouse temperatures can be maintained throughout the night with coke even though the weather be really cold.

Test No. 1. 18/2/35—20/2/35.

Test on a Dreadnought Boiler Heating 7 Houses (approximately 11,000 ft. of 4 in. pipe).

	Gas Coke.	Anthracite.
Fuel in lbs. consumed in twenty-four hours ...	1,512	1,638
Mean External Temperature 6 p.m.—7 a.m. ...	44·1°	45·5°
Mean Temperature of Glasshouses ...	57·7°	57·0°
Mean difference between Glasshouse and External Temperatures... ..	13·6°	11·5°
Comparison of Fuel Cost for maintaining 1° difference between Glasshouse and External Temperature	55%	100%
Banking period 11 p.m.—8,30 a.m.		

Test No. 2. 5/3/35—8/3/35.

Test on Thames Bank Boiler and Lamb Boiler Heating 4 Houses and Dutch Lights (approximately 3,800 ft. of 4 in. pipe).

	Gas Coke.	Anthracite.
Fuel in lbs. consumed in twenty-four hours ...	895	1,456
Mean External Temperature 6 p.m.—7 a.m. ...	31.8°	40.3°
Mean Temperature of Glasshouses ...	62.2°	64.8°
Mean difference between Glasshouse and External Temperatures... ..	30.4°	24.5°
Comparison of Fuel Cost for maintaining 1° difference between Glasshouse and External Temperature	36%	100%
Banking period 9 p.m.—7 a.m.		

Test No. 3. 18/3/35—20/3/35.

Test on Thames Bank Boiler and Ideal Boiler Heating 4 Houses (approximately 1,600 ft. of 4 in. pipe).

	Gas Coke.	Anthracite.
Fuel in lbs. consumed in twenty-four hours ...	532	840
Mean External Temperature 6 p.m.—7 a.m. ...	43.1°	44.0°
Mean Temperature of Glasshouses ...	61.6°	63.7°
Mean difference between Glasshouse and External Temperatures... ..	18.5°	19.7°
Comparison of Fuel Cost for maintaining 1° difference between Glasshouse and External Temperature	41%	100%
Banking period 9 p.m.—7 a.m.		

Efficient combustion of solid fuel.

The essence of the efficient combustion of solid fuel is the maintenance of a fire bed of even thickness. If the fire is too thin, or the fuel burns away in places to form air holes, excess air is admitted and has a cooling effect on the boiler. 100% excess air in itself means a fuel loss of 20%, and 200% a fuel loss of 30%. With many of the anthracite boilers seen in operation the excess air was above 200%. If the fire is too thick a loss of heat is caused owing to the formation of carbon monoxide, but this loss is not as serious as that obtained with excess air.

Owing to the desirability of an even fire, two points arise immediately:—

- (1) A graded fuel is necessary.
- (2) The grate area should be ample.

If a graded fuel is used of size bearing a relation to that of the boiler, combustion will take place regularly, and the fuel will burn evenly through the whole area of the grate, and

air holes will only be formed after a long period, when the fire bed becomes thin. If ungraded fuel is used, the smaller pieces will burn away and after a time leave the large lumps with spaces between them only containing a comparatively small volume of ash, and air holes form rapidly. The fact that coke is graded, whereas anthracite is ungraded, is a point in its favour and is probably the chief reason for the superior efficiencies obtained with the former in the tests on nurseries.

If the grate area is ample, the change in thickness of the fire is slower, and it can be maintained at efficient thickness for longer periods. Furthermore, the combustion of fuel per square foot of grate area being smaller, less clinker will be formed, which in turn enables the fire to be left for longer periods without cleaning, and minimizes losses due to unconsumed fuel being removed with the clinker.

Draught regulation.

Much fuel is wasted in nurseries owing to the crude methods employed for regulating the draught. Ashpit doors are infrequently used, and flue dampers are often inadequate and sometimes not existent.

Reduction of fuel cost.

In most nurseries a reduction of fuel cost by 30—40% can be obtained by overhauling or providing new boiler doors and flue dampers, and carefully selecting the fuel. In some cases, where the practice is to bank for eight to nine hours during the night, the fire box capacities of the boilers will make it necessary to use anthracite during really cold weather, but throughout the many comparatively mild nights during the year when the temperature does not fall below 40—45°F., with a little experience in the regulation of the draught, it will be found possible to burn coke with complete safety, and to obtain reductions in fuel cost equivalent to those obtained in the tests set out above. Coke is a lighter fuel than anthracite, and requires less draught; and it is always necessary to have an ashpit door and to take care that both this and the fire door of the boiler fit reasonably well.

In boilers of large fire box capacity, similar to those tested in Test No. 2, coke can be burnt throughout the year.

APPENDIX A.

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APPENDIX B.

Manurial Treatment in Tomato Experiments.**(1) Lime.**

All Houses except 11 and 12 received ground caustic lime at the rate of 2 tons per acre. In 11 and 12, plots 1, 3, 5 and 7 received lime.

(2) Stable Manure.

Houses 1, 2, 5, 6, 7—10, 11 and 12 received 15 tons per acre, except plots 5—8, house 2.

(3) Base-dressing.

Houses 1, 2, 5 received $\frac{3}{4}$ lb. per sq. yd. of the following mixture:—

- 1 part bone meal.
- 1 part bone flour.
- 1 part hoof and horn.
- 1 part sulphate of potash.

Houses 6, 7—10, 11 and 12 received $\frac{3}{4}$ lb. per sq. yd. of the following mixture:—

- 1 part bone meal.
- 1 part bone flour.
- 1 part sulphate of potash.

(4) Top-dressing.

Houses 1, 2, 5—12 received 2 ozs. per sq. yd. of the following mixture every 14 days at discretion:—

- 3 parts sulphate of potash.
- 2 parts dried blood.
- 7 parts 30% superphosphate.
- 5 parts pure dissolved bones.
- $\frac{1}{2}$ part bone flour.
- $2\frac{1}{2}$ parts sulphate of potash.

This gave 5% ammonia, 24% total phosphates, 12% soluble phosphates and 7% potash on examination,

APPENDIX C.

**Manures applied to Plots 1-3, and 14-16 in Tomato
Houses 3 and 4.**

Plot.	TITLE.	Base Manure in Lbs. per sq. yd.				† Top-dressing in Lbs. per sq. yd.			
		Lime.	Stable Manure.	Basic Slag.	Sulphate of Potash.	Super- phosphate.	Sulph. of Ammonia.	Nitrate of Soda.	Sulph. of Potash.
1	Complete Artificials (I.) without Nitrogen	1.0	—	0.4	0.1	0.5	—	—	0.2
2	Unmanured	1.0	—	—	—	—	—	—	—
3	Complete Artificials	1.0	—	0.4	0.1	0.5	0.2	0.2	0.2
14	Complete Artificials with Dung	1.0	7	0.4	0.1	0.5	0.2	0.2	0.2
15	Complete Artificials without Phosphates	1.0	—	—	0.1	—	0.2	0.2	0.2
16	Complete Artificials without Potash	1.0	—	0.4	—	0.5	0.2	0.2	—

† The Top-dressing was applied in eight equal instalments.

Manurial Treatment in House 3, and Plots 4-13 in House 4.

Detailed in Diagram on page 19.

$K_1 = 4$ ozs. sulphate of potash per sq. yd.

$K_2 = 4$ ozs. chloride of potash per sq. yd.

$P_1 = 6$ ozs. superphosphate and $1\frac{1}{3}$ ozs. dried blood per sq. yd.

$P_2 = 4$ ozs. bone meal per sq. yd.

APPENDIX D.

Dates of Cultural Operations 1933—1934.

Crop.	Sown.	Potted into 60's.	Potted into 30's.	Planted out in borders.	First Mulching.	First Top Dressing.	First Fruit Picked.	Last Fruit Picked.
Cucumbers ...	Dec. 29 1933	Jan. 9 1934	Jan. 23 1934	Feb. 16 1934	Mar. 9 1934	Mar. 16 1934	Mar. 26 1934	Sept. 7 1934
Tomatoes ...	Dec. 29 1933	Jan. 23 1934	—	Mar. 6 1934	—	May 8 1934	May 29 1934	Oct. 26 1934

Meteorological Records, 1934.

Month.	Air Temperatures				Grass Temp.		Rainfall			Mean Soil Tem- peratures		Hygrometer				Bright Sunshine		Baro- meter		
	Mean		Absolute		Av. Min.	Absolute Min.	Days No. of Days	Total Pre- cipitation	Greatest Fall	Soil Tem- peratures		Dry Bulb	Depres- sion of Wet Bulb	Relative Humidity	Dew Point	Total No. of Aver- Hrs. age.	Daily			
	Max.	Min.	Date	Tem.						1 ft.	2 ft.								°F.	°F.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.		°F.	
January	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
February	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
March	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
April	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
May	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
June	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
July	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
August	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
September	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
October	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
November	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
December	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Total rain for year, 19.67 ins. No. of days precipitation, 124. Total bright sunshine for year, 1483.0 hours.

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No. of days precipitation, 124.

Total bright sunshine for year, 1483.0 hours.

DIAGRAM SHEWING ARRANGEMENT OF EXPERIMENTAL PLOTS. 1934.

